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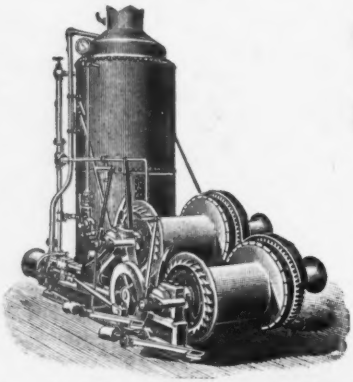

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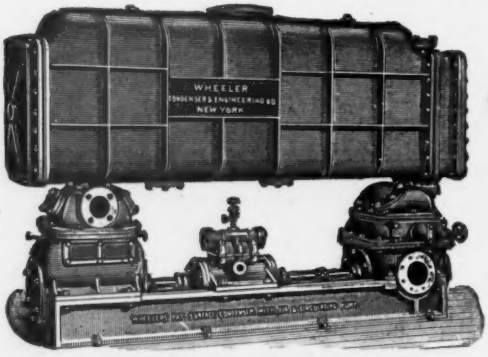

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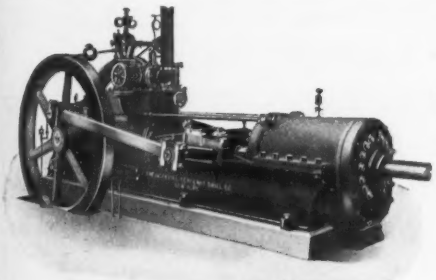

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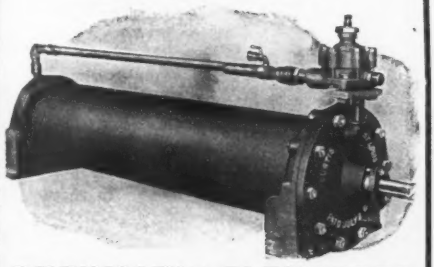

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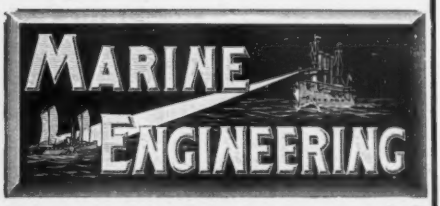

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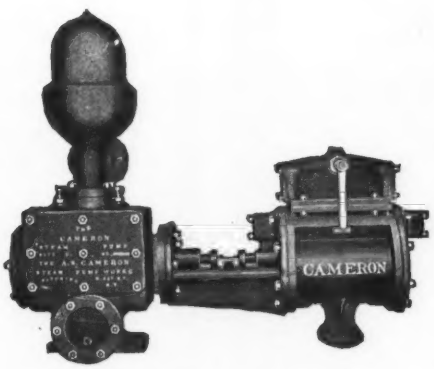

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VOL. IX. NOVEMBER, 1904. NO. 9

A Lesson from the St. Louis Fair.

The higher one climbs the broader the horizon becomes and the limitations of local landscapes are more clearly defined. As mankind advances along the path of industrial development, the wider outlook shows the narrowness which has often prevailed in the world of mechanical art. It is this widened outlook and broad-minded view which has resulted in the strikingly harmonious combinations of air and electricity seen at the Louisiana Purchase Exposition.

It is no new thing to see the once bitter rivals, compressed air and electricity, working side by side for a common object. We have many times mentioned this tendency and illustrated it with fresh examples of the combination of powers. As the World's Fair, which is now in progress at St. Louis, aims to show the wonderful progress made in industrial lines, so it has also served to demonstrate more fully than can any individual instance that compressed air and electricity are destined to work in harmony. It is true that there are points at which the provinces of these two powers overlap and there there must be a good-natured contest. It is equally true that there is a certain field which neither alone can cover, and it is in this neutral ground that compressed air and electricity have joined hands in harmonious working for mutual gain.

The many examples of electrically-driven air compressors, belted, geared and chain driven, seen at the Fair, are pleasing illustrations of this new era. They show to splendid advantage the possibilities of harmonious co-operation. The several systems of electro-pneumatic switch and signal systems exhibited show the happy result of combination; electricity being, as it were, the nervous force of the system and compressed air the muscular power. Almost the same is true of the electro-pneumatic system of car control exhibited by a prominent manufacturer. Here again electricity is the guiding or directing force, compressed air the operative agent.

The several types of traction car brakes exhibited, with motor driven air compressors as the basis of operation, reveal another acknowledgment of the mutual dependence of air and electricity in the street railway field. A builder who combines in his output both electric and compressing apparatus shows a portable cleaning set, with motor-driven compressors, suggesting a new field of united effort. A pneumatic street sprinkling car, with air compressed by a motor-driven compressor, shows possibilities in municipal health and comfort.

There are other instances of this co-operation. They all serve to illustrate the same great truth. Every factor in the universe has its duty to perform. In their narrow vision, men and forces may appear at enmity, but the great system of the universe allots to each its duty, where it may work in harmony with the rest.

Compressed Air on Warships.

Many will remember the terrible explosion which occurred in the after-turret of the United States battleship "Missouri" during target practice last spring. Sparks still remaining in the gun after firing ignited the charge of high explosive as it was placed in the breech preparatory to another shot. The explosion which followed communicated to the magazine below, and death was carried to the brave men there as well as those in the turret.

To prevent such a disaster, a stream of air from a small electrically-driven blower was turned into the guns after each shot and before the new charge was inserted. The air pressure was not sufficient, however, to assure absolute safety, so compressed air at 100 pounds pressure was substituted. The air was obtained from the pneumatic system used to operate doors and hatchways in the water-tight bulkheads. So far this method has proven very effective.

Heretofore compressed air has played but an unimportant part on the warships. Electricity is used almost universally and for a multitude of uses. A number of the battleships in the United States Navy are equipped with compressors for operating what is known as the "Long Arm" system for closing the doors and hatchways. This is done automatically and registers at the bridge, so the commanding officer may know exactly whether each door is open or closed. It would seem as if this system were capable of considerable development. Now that compressed air has proven so useful in removing all chance of danger after the firing of a big gun, it is likely that this power will receive more attention from the naval architects than it has in the past. The possibilities of air for operating hammers and drills and for painting purposes suggest that it may be used to considerable advantage.

Compressed Air at the Louisiana Purchase Exposition.

The St. Louis Fair, or, more properly speaking, the Louisiana Purchase Exposition, offers by all odds the most splendid opportunity yet afforded to study the latest developments in the field of applied mechanics. The very latest progress along all lines of mechanical art is shown in the countless machines of all types in the various exhibits. Probably to engineer and layman alike the display of electrical machinery is the most impressive, and such applications of electric power as the decorative lighting of the Fair and the flowing of the Cascades appeal even to those wholly unversed in engineering matters.

Electricity is conspicuously the presiding genius of the Exposition. But side by side with it, working silently and modestly, attracting little attention, doubtless wholly ignored by the vast majority of visitors, but bearing its large share of the burden, another form of power is contributing its part toward the success of the Fair. We refer to compressed air; and it is the purpose of this paper, exclusively devoted to the interests of air as a power, to call the attention of its readers to the part its special protege is playing in this great World's Fair.

As the air compressor is the basis of any compressed air system the exhibits containing air compressors may properly be first considered. The compressor installation of the Service Plant of the Exposition is furnished by Laidlaw-Dunn-Gordon Company, of Cincinnati, and is located in the Machinery Hall. It consists of two air compressors of standard type. The larger machine is of the "Cincinnati" type, designated as Class 15A, and at 125 R. P. M. normal speed it has a free air capacity of 1,300 cubic feet per minute. The feature of this type is the combination of poppet and mechanical air valves in the "Cincinnati" valve gear. The steam valve gear has the Corliss features of separate steam and exhaust valves, but the high speed forbids the use of Corliss release gear. Steam cylinders are compounded and air cylinders two-stage. The air from this machine is used for general supply purposes and its load has been very light. The smaller compressor is also of duplex

type, a compound steam-driven two-stage machine with a capacity of 520 cubic feet of free air per minute. The steam valve gear is similar to that of the larger machine and the air cylinders have semi-mechanical valves. The air output of this compressor is almost exclusively used in the Transportation Building.

Next in point of magnitude to the Service Plant is the exhibit of the J. George Leyner Engineering Works Company, of Denver, Colorado, in Block 81 of the Mines and Metallurgy Building. This firm shows three of its standard air compressors. Two of these are identical in free-air capacity, but one has compound steam cylinders, the other simple steam. The air ends are two-stage. The free-air capacity of these machines is 482 cubic feet per minute at 115 R. P. M., the rated speed. The feature of these machines is the steam valve, which is of adjustable cut-off piston type. The third compressor is a single stage belt-driven machine coupled to a Westinghouse motor and operating to furnish air for this and other exhibits in the same building. The capacity of this machine is 164 cubic feet of free air per minute at 150 R. P. M. All of these compressors are of the straight-line type and have poppet inlet and discharge valves. This company also shows several mine hoists of its make. It also shows a Leyner rock drill mounted on the regular tunnel column in a timber frame. This machine takes air from the smaller compressor and at intervals throughout the day an exhibition run is made, drilling holes in a large block of granite. Sectional models of the drill are also shown.

The Curtis & Co., Manufacturing Company, engineers and machinists, of St. Louis, has, in Machinery Hall, an extensive exhibit of air compressors, pneumatic appliances and saw-mill machinery. Among the several compressors are seen duplex and two-stage types, both belted and geared, all of vertical pattern. Two of these machines, motor driven, are in operation to furnish air for purposes in this exhibit. One of these applications is seen in the company's latest sawmill, where air is used for exhibition purposes instead of steam in the cylinder of a "steam-feed" mill, representing the latest development in saw machinery. Three Curtis pneumatic traveling cranes are shown, in capacities from 800 pounds to 10 tons. A Curtis pneumatic freight elevator of 2,500 pounds capacity, as well as a rope elevator of one ton capacity, with dumb waiters, package lifts and air hoists, are all shown in operation. All of these pneumatic appliances are characterized by the devices manufactured and controlled by the Curtis Company. Outside of the regular exhibit of this company, it has a traveling crane, a cupola elevator and several air hoists in operation in the Foundry Building, beside two ice cranes in the World's Fair ice plant.

In Machinery Hall, the Chicago Pneumatic Tool Company shows a small straight line steam-driven compressor not in operation. It has a capacity of 160 cubic feet of free air per minute at 74 R. P. M. and has simple steam and air cylinders. In the same space this company shows a complete line of pneumatic tools—chipping and riveting hammers, sand sifter, pneumatic tamper, stay-bolt cutter, stone dressing machine, etc. It is an interesting exhibit of compressed-air appliances for the minor manufacturing processes. The American Well Works Company, of Aurora, Ill., has a handsome exhibit of two of its standard straight-line steam-driven air compressors, both single and two-stage. The finish of these machines, in ivory white and polished metal, gives a striking effect. Fairbanks, Morse & Company, of Chicago, has a very large exhibit of gas and gasoline engines. Among them is seen a gasoline engine air compressor of small size. The machine is very similar in design to the standard engines of the company, but has an air cylinder in line with the gas cylinder, the crank and shaft being mounted between.

In the Palace of Electricity the National Electric Company, of Milwaukee, shows one of its standard car compressors for air-brake work. This is a motor-driven duplex single-stage machine having a capacity of 75 cubic feet of free air per minute to a pressure of 100 pounds. It is in operation to furnish air to another part of their exhibit, consisting of a standard three-car air-brake equipment, illustrating the company's system of multiple-unit car control. This is an operative exhibition of the Christensen air brake for street cars and the operation is clearly shown. A school or

practice brake set is also exhibited, such as is installed by tramway systems for instruction of their motormen. The compressed air part of this company's exhibit is completed by a portable compressed air outfit consisting of a compressor and motor, receiver and cooler mounted on a truck. Besides these items an extensive line of electrical apparatus is shown.

The General Compressed Air Cleaning Company, of St. Louis, in its space in the Manufactures' Building, exhibits one of its standard portable cleaning sets, containing air compressor, receiver, etc. The space is fitted up to represent a house with carpets, hangings, etc., and actual operation of the various cleaning tools is shown. This is a very popular exhibit with the ladies and the demonstrations draw large crowds of the fair sex.

Air compressors not strictly on exhibition are seen in operation at two points on the grounds. The Ayer & Lord Tie Company, of Chicago, has an operative exhibit of its timber-preserving process on the grounds, near Intramural Station No. 12. The process is one by which the moisture is withdrawn from timbers and creosote forced into every pore. In one stage of the treatment—that of removing superfluous creosote—air under pressure is required, and for this purpose a small single-stage steam-driven compressor is used, built by the Clayton Air Compressor Works. The machine is of standard type and is seen in actual operation.

Another interesting Fair attraction, in which compressed air is an incidental feature, is the engine-room of the Tyrolean Alps. Here about 750 H. P. of Deisel oil engines are installed, driving generators to light the Alps. The Deisel engine uses an explosive mixture of oil and air, the oil being injected into the cylinders in a fine spray. For this purpose an Ingersoll-Sergeant Class "EC" high-pressure air compressor is used, belted to an electric motor. This machine furnishes air at about 750 pounds pressure. It is a compound compressor, the air cylinders, valves, piping, etc., being wholly enclosed in a cast-iron water box and submerged in cooling water. The machine has been giving excellent results, furnishing air under pressure for the entire plant. This engine-room, located near the main entrance to the Fair and open to the view of the public, rivals the features of the Pike as an attraction and arouses the keenest interest in all beholders.

The other exhibits may best be considered by taking one of the buildings at a time and looking at the features of interest they contain. As might be expected, Machinery Hall is rich in its interest to the compressed air man. The Standard Railway Equipment Company, of St. Louis, has, in Block 29, a most complete line of pneumatic appliances. Among them were noted chipping and riveting hammers, rotary drills, pneumatic chain hoists, flue expanders, compression riveters, sand shakers, stay-bolt cutters and pneumatic painting machines. Some of these were in section to show construction and some in operation with air from the Service Plant. Not far distant is the space of the Reliance Machine and Tool Works, St. Louis. Among the features of their exhibit are seen pneumatic stay-bolt cutters and pneumatic stay-bolt breakers. This is not an operative exhibit. The Brown Hoisting Machinery Company, of Cleveland, shows a line of its products, among which is a large locomotive crane or excavator. While primarily a steam-driven machine, it is shown in operation at intervals, using compressed air from the Service Plant instead of steam. Such substitutions as this suggest possibilities of air as a power to the mind of the thoughtful observer. Another example of this substitution of power is seen in the space of the Niles-Bement-Pond Company, where a 20-ton steam hammer is in operation with compressed air from the Service Plant. In this same exhibit was noted one of the newest and most interesting applications of compressed air to shop economy. This is the pneumatic reversing clutch on a huge motor-driven planer. On this machine the speed ratio of forward and return strokes is 27 to 75. The heavy platen (it is a 10-foot planer) is reversed by means of a pneumatic clutch operated by an air valve thrown by a trip on the platen. Even at high cutting speeds this device gives an easy reversal with little shock to the structure. The same exhibitors show a small automatic magazine machine along the lines of a turret lathe. The novel feature of this is a pneumatic chuck, which grips and releases the stock shapes at the proper time. Its action is positive and

instantaneous. Air from the Service Plant operates both planer and lathe. In Block 8 of Machinery Hall, the William Sellers Co., of Philadelphia, shows, among other machine tools, a 96-inch by 96-inch by 20-foot planer with pneumatic reversing clutch. The results secured in this machine are the same as those stated above with the Niles planer. The two clutches are similar in principle, but differ in details of construction and operation. The weight of the platen of this planer is 23,000 pounds, yet the reversal is easy and noiseless at highest speed.

In the Transportation Building, as might be expected, compressed air is seen in its applications to the problems of transportation. Prominent among the exhibits is that of the combined Westinghouse companies. A most pleasing and novel feature of this is the Russian kiosk, built in Russia by Russian labor and shipped to the Fair by the Russian Westinghouse interests. It occupies a prominent place at one end of the exhibit space, and in it Russian girls in native costume serve tea and "suchari" in token of Westinghouse hospitality. The exhibit of the Westinghouse Air Brake Company includes two distinct features of compressed air interest. One is a rack made up of the apparatus constituting the standard equipment of a six-coach passenger train with engine and tender. A novel feature is that all valves are in duplicate, one being in section and connected to the other so that the action of the devices is clearly seen. The rack includes the high-speed brake and signal equipment, and engine and tender are also equipped with the combination automatic and straight air brakes now in use. The engine carries two air pumps. The second feature of the exhibit is the rack showing the straight air-brake equipment on electric cars carrying their own compressors. The compressors shown are of both axle- and motor-driven types and are in section. One is arranged to move in unison with a regular compressor in operation. The American Brake Company shows a model of the outside equalizing brake for locomotives, and also the American slack adjuster. The Westinghouse Automatic Air and Steam Coupler Company shows the ends of two freight cars with the company's devices in actual operation. Two small models also show the operation of the automatic air, steam and signal coupler. The exhibit of the Union Switch and Signal Company includes a group of standard railway signals, full size and in working condition, beside a signal specially designed for use in the tunnels of the Pennsylvania Railway, in New York, shown in position in the full-sized section of one of the tunnel tubes.

The New York Air Brake Company has a striking exhibit of modern automatic and straight air-brake equipments. It includes a freight rack representing a train of 60 cars, having the same number of feet of piping, the same number of hose couplings, valves and accessories that go to make up a regular train of this length. Most of the brake cylinders are eight inches in diameter, but a number of 10-inch cylinders are introduced to show the harmonious working of the different sizes. Another rack shows a passenger train of 15 cars made up with the latest modern high-speed equipment, including various sizes of cylinders from 10 to 16 inches in diameter, equipped with the company's high-speed compensating valve and the various reservoirs, angle cocks, piping, etc., properly belonging to an equipment of this character. In a third rack is shown the signal equipment for a 20-car passenger train, with all fittings and accessories as in actual service. Other features of this exhibit are sections of the various devices showing their construction: air pumps, triple valves, engineer's brake valve and the high-speed compensating valve shown in section working in tandem with a complete device of the same kind. Of special interest is a large No. 5 Duplex Air Pump for heavy brake service. In this same exhibit appears a train-order signal made by the Train Order Signal Company, of New York. The device, located in the engine cab and belted to the engine truck wheel, can be set for any future event of which it may be necessary to remind the engineer, such as meeting points, expiration of orders, slow-track orders, etc. Upon approaching the point where it is necessary to bring the train to a stop a warning whistle is blown and, should this be disregarded by the engine crew, the device will automatically apply the brakes. A number of different points can be set at one time on the device.

In the same building the General Railway Signal Company, of Buffalo, has a very complete exhibit of low-pressure pneumatic switches and signals, together with photographs of numerous installations made. Air for this exhibit is furnished by a small motor-driven compressor, and the various appliances are shown in operation. The Goodwin Car Company, of New York and Chicago, shows a steel dumping car with pneumatic dumping apparatus operated by air taken from the train pipe. In a neighboring section the McGuire-Cummings Manufacturing Company, of Chicago, has one of its pneumatic street-sprinkling cars, air pressure being supplied to the tank by a small motor-driven compressor on the car. A novel application of compressed air, purely for exhibition purposes, is seen in the exhibit space of the National Malleable Castings Company, Indianapolis, where full-sized models of "Climax" and "Tower" car couplers are shown in operation. Air is arranged to periodically bring the models together, make the coupling and break it. The important part which compressed air plays in the problems of modern transportation is impressively shown in the Transportation Building.

In the Palace of Electricity the Westinghouse Electric and Manufacturing Company has a working model of the electro-pneumatic train control system. Air is furnished by a small motor-driven compressor. The controller turret is mounted in a frame, where the electric switches, switch cylinders and other details are plainly seen. The electrical connections lead to a standard two-motor railway truck, and the speed variations by the system appear distinctly. The exhibit of the National Electric Company in this building has already been noted. The General Electric Company shows motor-driven air compressors in connection with the model exhibit of the Sprague multiple-unit system of train control.

In the Mines and Metallurgy Building the exhibit of the Leyner Engineering Company has been mentioned. An interesting application of air from this exhibit is seen in the space of the Standard Oil Company. A number of large vertical glass tubes are filled with various oils and air is admitted at the bottom, bubbling up through the oils and showing their comparative viscosity. On the south aisle of this same building Edgar A. Weimer, Lebanon, Pa., shows a large slag car for smelters, with a pneumatic dumping arrangement. A small motor-driven compressor furnishes compressed air for operation of this device.

In the Manufactures' Building the Nichols Manufacturing Company, of Ottumwa, Ia., shows a Hardsog Little Wonder Air-Rock-Drill. No demonstrations are given. In the Government Building, in connection with the exhibit of the Post Office Department, a complete pneumatic tube system for distributing mail is shown. The equipment was installed by the American Pneumatic Service Company, of Boston, and represents the latest practice along these lines.

One of the most novel and beautiful details of an exhibit is the soap-bubble fountain advertising "Fairy Soap" for the N. K. Fairbanks Co. The fountain is found in the Manufactures' Building and depends for its artistic and novel features upon the use of compressed air. The figure of a fairy stands at the top and beneath is a basin of soap solution. Air passing up through the solution produces a mass of soap bubbles which overflows the basin and follows down over the surface of the pedestal into a bowl below. Electric globes behind the sheet of bubbles illuminate them, giving the effect of an ever-changing iridescent mass in every color of the rainbow. This exhibit attracts a great deal of attention by its delicate beauty.

Another novelty in which compressed air plays an important part is the huge floral clock on the slope to the north of the Agricultural Building. The dial is 112 feet in diameter and is a mass of flowering plants. The Roman numerals are 15 feet in length, worked out with flowers. The hands of the clock carry flowers and vines. The driving mechanism, controlled and operated by compressed air, is located in a small pavilion above the clock, and includes the air compressor, air motors and an astronomical clock. This master clock admits air each minute to the clock motors, moving the huge arms the proper distance through shaft and bevel gears. The pavilion, which is of plate glass, also contains a terrestrial globe which shows the time at every place in the world. To the west of the pavilion stands a large

bell; to the east, a huge hour glass. On the hour, the master clock releases air which rings the proper number of strokes on the bell and reverses the hour glass. Aside from that contained in the pavilion, the entire mechanism of the clock is hidden with flowers and vines. The equipment was installed by the Johnson Service Company.

It has been the intention of this article to cover the field of compressed air at the Exposition thoroughly. If any exhibit has been omitted from these notes it is hoped that it will be understood to be an oversight on the part of the observer. It is not the intention of this paper to omit any exhibitor, and if such omission has occurred, it has arisen in the multiplicity of exhibits at the great Fair. Enough has been said to show that compressed air is playing an important part in the St. Louis Fair, and a study of its applications there shown will impress the thoughtful observer with the diversity of the field and the flexibility of compressed air as a transmitter of power.

River Wells and the Horizontal Delivery of Water.*

In this paper it shall simply call your attention to certain results which are being obtained every day with the air-lift system of raising water. These results apparently upset some of the older conclusions, one of which is that water cannot be delivered horizontally to greater distances than from 30 to 50 feet.

The first case is that of a well drilled in the bed of a river, and furnishing water for steam making. The water from an ordinary drilled well in this locality would have to filter through sand and gravel, and thus become impregnated with lime and other scale-making matter which renders it unfit for boiler use.

The horizontal distance from the tank to the well is 511 feet; the depth of the well, 135 feet; the perpendicular height between the well and the top of the river bank, 40 feet, and the distance from this point to the top of the tank, 20 feet, making a total lift from the lower water level of 60 feet. The river rises and falls from 2 to 50 feet measured in the channel; consequently the depth of submersion and the ratio of submersion to lift varies between wide limits. The conditions in this plant at present are such that it is not practicable to make a test, but later on I hope to obtain some information concerning the efficiency, which, judging from the results of general observation, would seem to be very satisfactory.

The well was drilled in the following manner: A 10-inch pipe was driven into the bed of the river to a depth of 6 or 8 feet, then the dirt and gravel was taken out, and the pipe again driven down until rock was reached, which was found at a depth of 50 feet. The 10-inch pipe was used merely as a caisson to keep out the dirt while the drill was at work. From the 50-foot level, an 8-inch hole was drilled to a depth of 85 feet, thus making the total depth 135 feet. An 8-inch pipe was then plugged at one end and lowered into the well, the pipe representing a long tube closed at the lower end. On the upper end of the pipe was a cast iron tee, 10 by 10 by 8 inches, the top of the tee containing a slot large enough to admit a 3-inch pipe. One end of the tee was fitted with a piece of 10-inch pipe 6 feet long, perforated with ¼-inch holes, and capped at one end. This provided a suitable strainer to keep out leaves and other floating matter. A 3-inch and a 1¼-inch pipe was then connected up, the 3-inch pipe being perforated with holes for a distance of 5 feet from one end, this serving as another strainer. About 2 feet from these perforations a hole was bored and tapped to receive the 1¼-inch pipe. The two pipes were then lowered into the 8-inch pipe through the slot in the tee, additional pipe being screwed on until the 3-inch pipe rested on the bottom. The pipe was then bent to an easy curve of 90 degrees.

To the outer end of the 3-inch pipe was connected the horizontal discharge main. This main did not run in a straight line, but was laid in the same manner as the discharge line from an ordinary pump. A band was then put around the slotted end of the tee and made air tight. This was done for two reasons, first, to keep dirt

*A paper read by G. C. H. Friederick before the Ohio Society of Mechanical, Electrical and Steam Engineers.

out of the well, and, second, so that the air could be reversed for the purpose of cleaning by blowing out anything that might have become lodged against the strainer and in this simple manner keep the well in good working order. The current of air is reversed by placing a gate valve at a convenient point in the discharge line, then by simply closing it for a few moments the air passes up on the outside of the 3-inch discharge pipe and into the 8-inch pipe and thence into the 10-inch perforated pipe. The pressure of air being much greater than the water pressure, any foreign matter that may have lodged against the strainer will be blown away and carried off by the current of the river.

The remainder of the apparatus consists of an air compressor and air tank, and as mentioned in a former paper, the air compressor is located in the engine room. This lift is in daily operation and has given no trouble, nor has it necessitated any expenses other than the cost of operating it.

The air pressure required to operate the lift at low water is 55 pounds to start the flow with a drop to 50 pounds when properly working. The highest pressure is 75 pounds, which corresponds to a depth of 45 feet in the channel. About 45 cubic feet of air are required to deliver 60 gallons of water or about 8 cubic feet, which is equivalent to about 7 horsepower. This amount of power, however, should not all be charged to the well, because the compressor in this case is too large for the work, which renders it necessary to run it too fast in order to avoid the dead centres. The air is throttled between the receiver and the well, which causes the receiver pressure to reach the blowing-off point. It will be readily understood that the conditions are not at all favorable for a test, but this will be remedied in the near future, and as soon as we can effect the desired changes I hope to be able to furnish additional data of a reliable nature.

Another lift of the same general construction, which was installed a little later, also has a horizontal discharge, the distance from the well in the river to the tank being 862 feet, with a total lift of about 50 feet. The depth of the well is 185 feet. The construction is substantially the same as the one previously described, with one exception, viz., at 40 feet from the well, the 3-inch pipe is connected to a 4-inch, the latter having five 90-degree ells near the discharge end. This was found necessary in order to deliver the water at a given point. At a distance of 40 feet from the well the 1¼-inch air pipe is connected to a 2-inch, the latter size being carried to the receiver.

Another system will shortly be installed having a horizontal discharge of 1,002 feet and a lift of 100 feet. I hope to give a thorough description of it when completed. I have every reason to believe that water can be successfully delivered at a distance of one-quarter of a mile, but the efficiency will be reduced considerably below that of a vertical lift.

The convenience and economy of the air lift appeals to every engineer where it is practicable to install this system of handling water, whether for manufacturing or supplying water for small towns. In the latter case, the lift oftentimes can be operated in connection with the lighting plant, and thus not only reducing, but in many instances eliminating entirely the cost of a separate pumping plant and the attendant operating expenses.

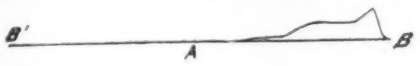
Study of Air Compressor Valves.

As very little is known in regard to the general action of automatic valves in small air compressors, the writer considers it might be of interest to give an account of a recent series of tests which he was called upon to perform.

The object of these tests was to make a thorough study of the action of the valves and also the usual velocity of the air through these valves. The machine which was tested was of ordinary type—it being a 7-inch by 7-inch belt-driven machine of the Blanchard type. The results may be considered as those which are likely to be found in the general run of the machines.

In order to accomplish this a steel rod ⅛ of an inch in diameter was screwed into the bottom of the discharge valve, this rod having a piece of brass wire soldered to the top. The brass wire was used as a marking point. This is shown by a sketch, No. 1. An indicator drum A fastened to the discharge pipe was actuated by a crank and connecting rod as shown. The ratio of $\frac{B}{C}$ was made equal to the main crank and connecting rod. The valve crank B was placed 90 degrees behind the main crank. This being done so that the resulting cards would more accurately show the exact point of opening the valve, which will readily be seen when the resulting cards are explained.

By the preceding device a card similar to the following could be obtained, in which the ordinates represent the lift of the valve and the abscissae represents the corresponding point of the stroke. The middle point of the stroke line A corresponds to the end of the stroke on the valves, whereas the ends B and B^1 correspond to the middle of the stroke of the piston. See following diagram.

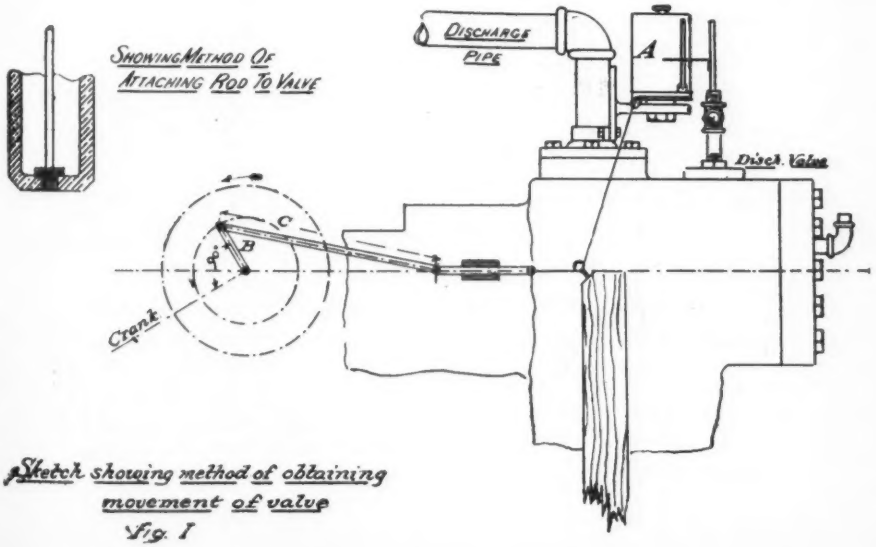


A series of these cards were taken at 100 revolutions per minute and at 132 revolutions per minute at different pressures. The following shows the manner of ascertaining the amount of the opening of the discharge valve at different points of the stroke.

First—The length of the valve cards were measured, from this, knowing the ratio of the crank to the connecting rod, the length of the connecting rod corresponding to any length of card could be found. For instance, if $\frac{r}{l}$ = ratio of crank to connecting rod, and C = length of card in inches (as measured); the corresponding length of the connecting rod is $x = c \times \frac{l}{r}$

Second—Taking valve card, draw a circle AEFBD as shown by Figure No. 2, which represents the crank circle. The rotation of crank being in a left handed direction, lay off $CG = \frac{r^2}{l}$ where $r = \frac{1}{2}$ the length of the valve card, and $l = x$ = the corresponding length of the connecting rod.

Third—Having done this, the original



Sketch showing method of obtaining movement of valve

Fig. 1

valve card, shown at AK WJI was transferred so that the displacements coincided with the piston displacements. To do this, take any point K on valve card and draw a line JK perpendicular to AB, through J draw GJH intersecting the circumference of the crank circle at H, from H draw HC, and, through the point I, where this line intersects AB, draw IE perpendicular to AB, then will OE be the position of the valve crank corresponding to the point K on the valve card. But as the valve crank is 90 degrees behind the main crank, the position of the crank OF must be laid off 90 degrees ahead of OE. This, then, represents the position of the crank corresponding to the point K of the valve diagram. To find the position of K, had the valve crank coincided with the main crank, proceed as follows: draw FN perpendicular to AB, and through N, draw CNL, and through the intersection L of CNL with the valve crank circle, draw LG, intersecting AB at O. Erect a perpendicular to AB at O, and draw KM, parallel to AB, intersecting OM at M, and then M will be the position of K when the main crank and valve crank coincide. In a similar manner the curve AJWK was reproduced at BMV' B, the displacements of the latter coinciding with the piston displacements. The above construction may be shown to be correct by the following proof, see Figure 3. l is the connecting rod and r the crank, by striking an arc with D as a centre, and radius equal to l, we get the point R which is the relative position of the crosshead for the crank position AB.

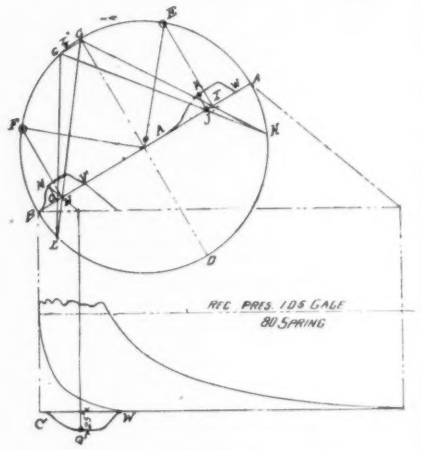


FIG. 2.

Lay off TM $= r_1 = \frac{r^2}{l}$ in the direction of motion of the crank. To prove that the point R may be found by the previous construction of first dropping a perpendicular from B on to PD, then drawing NT, and through Q, the intersection of NT and the circumference of the crank circle, QM; then will OM intersect PD at R.

$$\overline{DB}^2 = l^2 = r^2 + a^2 - 2ra\cos\beta$$

$$a = l - c$$

$$r\cos\beta = -r\cos(180^\circ - \beta) = -(c - u)$$

$$\therefore l^2 = r^2 + (l-c)^2 + 2(l-c)(c-u)$$

$$= r^2 + l^2 - 2lc + c^2 + 2lc - 2ul - 2c^2 + 2uc$$

but $l = r^2/r_1$ and $l^2 = r^4/r_1^2$

$$r^4/r_1^2 = r^2 + r^4/r_1^2 - 2cr^2/r_1 + c^2 - 2ur^2/r_1 + 2cr^2/r_1 - 2c^2 + 2cu$$

and $r^2 - c^2 = 2r^2u/r_1 - 2uc$

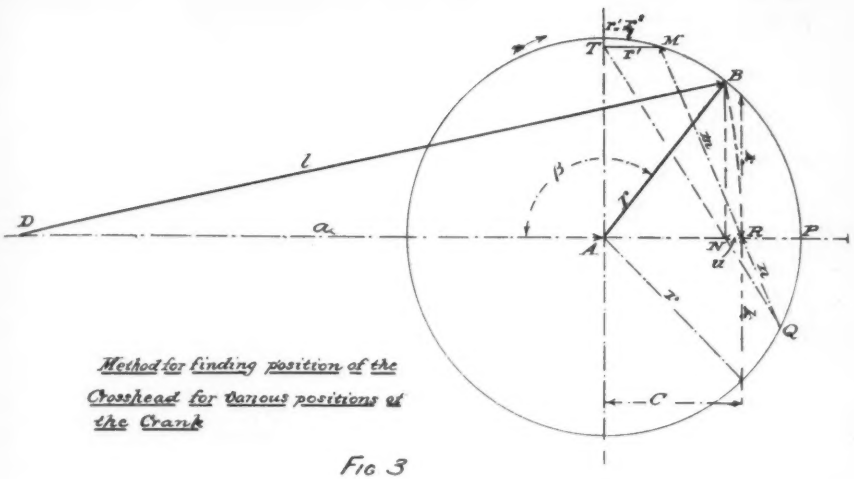
$$u/r_1 = r^2 - c^2/2r^2 - 2cr_1$$

$$r_1/u = 2r^2 - 2r_1c/r^2 - c^2$$

$$r_1 - u/u = r^2 + c^2 - 2cr_1/r^2 - c^2$$

and $u/r_1 - u = r^2 - c^2/r^2 + c^2 - 2cr_1$

$u/r_1 - u$



Method for finding position of the Crosshead for various positions of the Crank

FIG 3

$$r^2 - c^2 = k^2$$

therefore $m^2 = (c - r_1)^2 + (r^2 - r_1^2)$

$$= c^2 - 2cr_1 + r_1^2 + r^2 - r_1^2$$

$$= c^2 - 2cr_1 + r^2$$

therefore $u/r_1 - u = k^2/m^2$

further $k/m = n/k$

therefore $k^2 = mn$

and $u/r_1 - u = k^2/m^2 = mn/m^2 = n/m$

or $r_1/u - 1 = m/n$

therefore $r_1/u = m + n/n$

which shows that Q, R and M are on the same straight line and therefore this construction to determine R is correct Q. E. D.

Referring again to Figure 2 the next step is to transform this curve V^1MBN (which, by the way, represents the motion of the valve, and whose relative displacements coincide with those of the piston) to the same length as the valve card. This is done as shown by a common construction, obtaining points on line V^1B which are then transferred to the line C^1W. The valve curve is then laid off as shown at C^1 Q^1 W^1. As an illustration, the point K goes first to M then to Q^1. Thus we have a curve C^1 Q^1 W^1 which gives the lift of the valve for various piston displacements.

The following set of cards were obtained in the preceding manner for different pressures, all were taken at a speed of 100 revolutions per minute (Figs. 4, 5, 6 and 7).

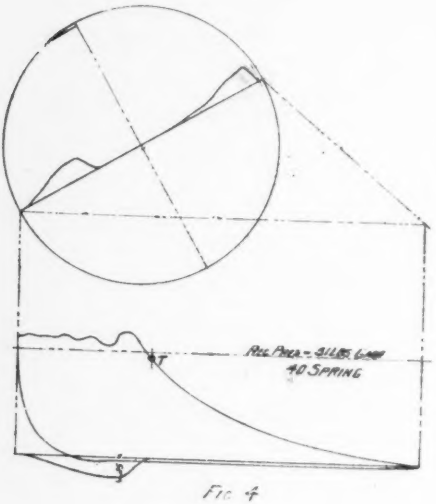


FIG 4

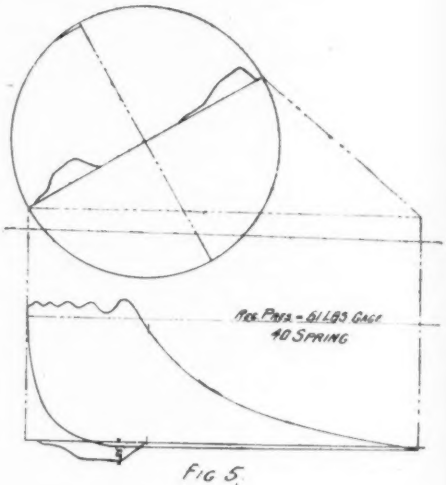


FIG 5.

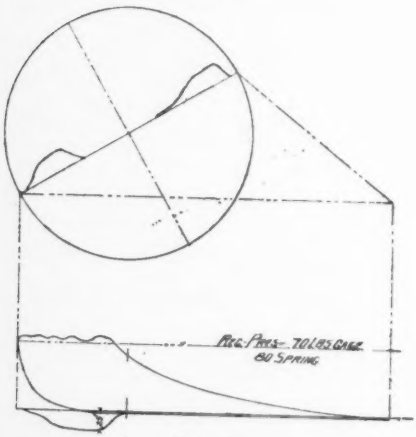


FIG 6

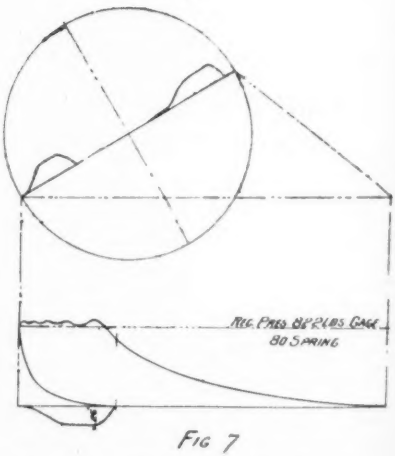


FIG 7

DISCUSSION OF PRECEDING CARDS.

Starting with card Figure 4 with 51 pounds gauge pressure, it is found that the pressure recorded by the indicator is above the gauge pressure; this is due to the friction caused by the smallness of the pipe which conveys air to the receiver. Also the point T gives a position on the indicator card when the valve begins to open. This pressure is lower in the cylinder at this point, than the pressure in the receiver; this is to be expected, as a certain time is needed to equalize the pressure.

On the other hand, it will be seen that the valve area seems to be sufficient, since before the valve is opened, one-fifth of its total lift, the pressure has become equalized. This is true for all pressures, show-

ing that the action of the valve is very prompt and has sufficient discharge area.

The second conclusion to be drawn from these cards is that the lift of the valve increases slightly with the increase of the pressure. This is caused by a slight leak by the wire for high pressures. Thus, owing to this leak, the pressure of the air on the back of the discharge valves is less than the pressure of the discharge, there is then a greater unbalanced force tending to lift the valve at higher than at lower pressures. Ordinarily, the only unbalanced force which keeps the valve closed is the tension of the spring, but if there is a slight leak, the tension of the spring is no longer the unbalanced force, but is decreased by an amount equal to the difference of the pressure of the discharge and the pressure on the back of the main valve.

For instance, if p_1 is the discharge pressure, and p_2 (which, by the way, is less than p_1) is the pressure on the back of the valve for high pressures; let T be the tension of the spring. Then, for low pressures, force tending to keep the valves closed, is $(p_1 + T) - p_1 = T$, whereas, for high pressures it is $(p_2 + T) - p_1$, which is less than T.

The third conclusion to be drawn from the cards is in the general opening and closing of the valves. It will be seen that the valve diagram, just as the valve reaches its maximum opening, is a curve, which shows that there is a gradual diminution in the velocity of opening as it nears its maximum lift. This is also true in the seating of the valve, shown by the curve becoming tangent to the line, and not making a sharp angle with it. This action is brought about by the seating of the valve on a cushion of air. The valves work with perfect quietness for all pressures. Further, the air which is compressed behind the valve, helps to close the valves more quickly and in every case the valve is fully closed at the beginning of the return stroke. This cannot very easily be seen from the photographs, as the curve is so gradual at that part of the stroke, but it may be seen from the various indicator cards of different pressures.

The fourth point, which is very nicely shown, is the gradual decrease of the length of time the valve is open for increasing pressures. This of course is to be expected owing to the decrease in volume of air discharged for increase in pressure.

The following cards were taken when the speed was 132 revolutions per minute. These are the original cards and are off-set 90 degrees from the crank (Figs. 8, 9 and 10).

Fig. 8

Fig. 9

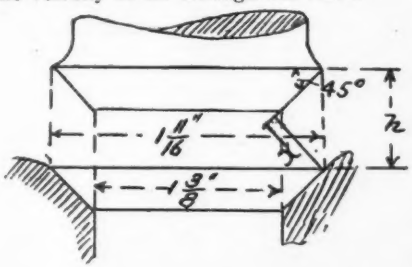
Fig. 10.

The preceding cards, taken at 132 revolutions per minute show a greater lift than those taken at 100 revolutions per minute. This is necessary owing to the greater piston velocity. In all other respects these cards are similar to the others, showing that the general movement of the valves is as good at this speed as at 100 revolutions per minute.

Velocity of Air through Discharge Valves.

To determine the velocity of the air through the discharge valves, it is necessary to know the average velocity of the piston for that part of its stroke during which the discharge valves are open. Knowing this, and also knowing the average amount the valve is open, the velocity can be calculated.

Thus let D equal the diameter of the piston; v equal the velocity of the piston; d equal the mean diameter of the valve; h equal the mean lift of the valve; V equal the velocity of air through the valve.



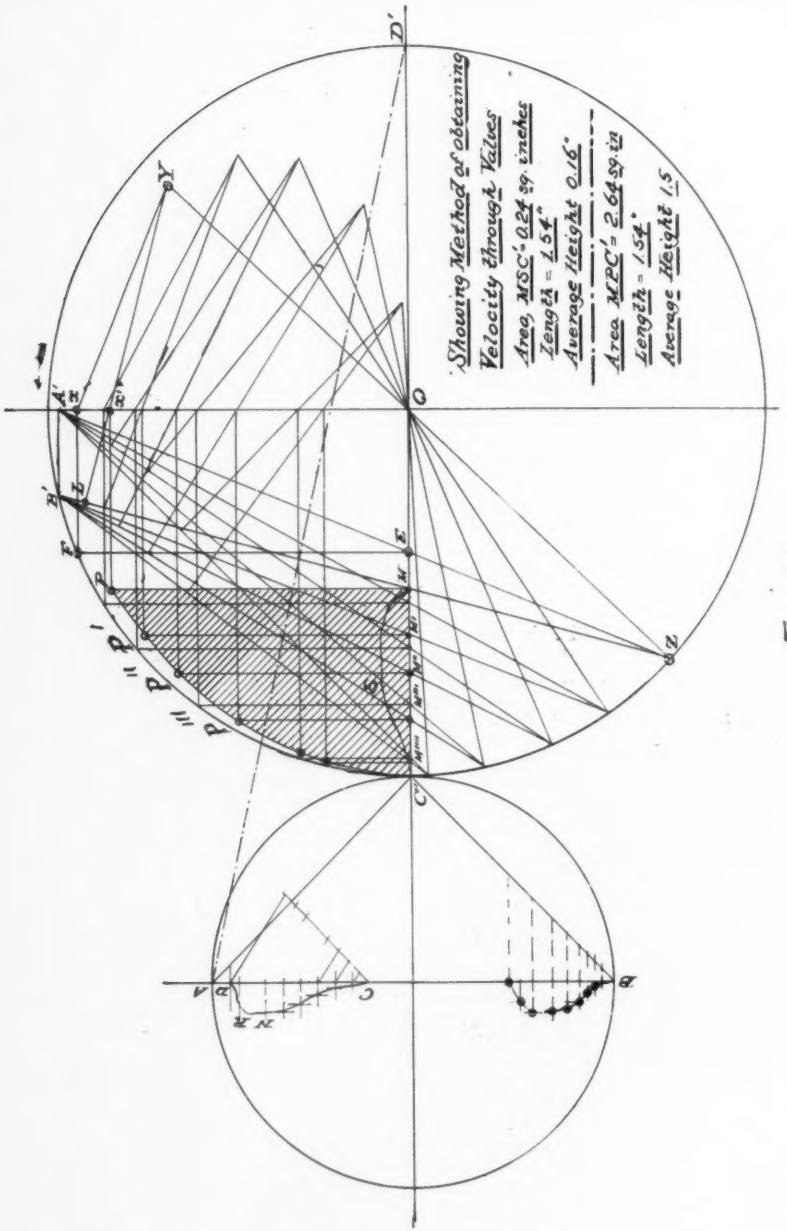

Showing Method of obtaining
Velocity through Valves
Area MSC' = 0.24 sq. inches
Length = 1.54"
Average Height 0.16"
Area MPC' = 2.64 sq. in
Length = 1.54"
Average Height 1.5
D'
O
Y
A
X'
B'
B
F
E
P
P'
P''
P'''
C'
M
N
R
S
C
A
Q

FIG. 10.

$d_1 = 1\,3/8''$ $\quad d_2 = 1\,11/16''$

$d = d_1 + d_2/2 = 1.375 + 1.6875/2$

$= 1.531$ inches.

Area through valve $= \pi dx = \pi dh \cos 45°$

Also $V/v = \pi D^2/4 / \pi dh \cos 45°$

$= \text{constant}/h$

$V = cv/h$

Next, to determine the mean velocity of the piston for that portion of the stroke during which the discharge valve is open: See Figure 10; the card at the left of the page shows a valve card taken at a speed of 100 revolutions per minute, and with an absolute pressure in the receiver of 90.1 pounds per square inch. This curve DRNC was first transposed to coincide with the crank and afterward enlarged to correspond with a crank three inches in length, giving finally the curve MSC^1.

The velocity of the piston was next determined; $A^1 B^1$ was laid off as in the previous work, $= \frac{r^2}{l}$, r in this case being three inches, therefore,

$$l = \frac{18.625}{3.5} \times 3 = 15.96'', \text{ therefore } \frac{r^2}{l} = 0.56''$$

where 18.625 inches = length of connecting rod and 3.5 inches = length of crank.

Take a number of points on MC^1 viz., — M, M′, M″, M‴, M⁗, these, then, represent the position of the piston, and the velocities of the piston at these points is determined as follows:

Take the point M, through M draw B′M intersecting the crank circle at Z, draw ZA′intersecting C′D′ at E, at E erect a perpendicular EF, then will FO be the position of the crank corresponding to the position of the piston at M.

Next draw Fx, through x draw xy perpendicular to A′Z and through y, the intersection of xy and ZO, draw yL perpendicular to B′Z, intersecting OA′ at x′, draw x′P parallel to D′C′, intersecting the perpendicular MP; then MP represents the velocity of the piston at the point M, the radius OD being taken as unity. Knowing MP we can determine the actual velocity of the piston at the point M by multiplying the ratio of the length PM to the radius OD′ by the velocity of the crank.

Thus let the length MF = 2.48″

The velocity of crank in inches per second

$$= \frac{100 \times 2\pi y}{60} = \frac{100 \times 2\pi \times 3.5}{60}$$

then will $\frac{\text{velocity of piston at M}}{\text{velocity of crank}} = \frac{2.48}{y} = \frac{2.48}{3.00}$

therefore velocity of piston at M

$$= \frac{2.48}{3.00} \times \frac{100 \times 2 \times \pi \times 3.5}{60}$$

or velocity of piston at M = 30.29 inches per second.

Proof, see Figure 9.

The principle of Dubost can, as shown above, be applied to the determination of the velocity of the piston. Let OM be the crank, Figure 11 OA′ the displacement of the piston when the length of the connecting rod is infinite, and OA that corresponding to a finite length of rod. If the connecting rod is infinite the velocity of the piston will be ω OB′ and **when the rod is of finite length ω OB′**, where ω = the angular velocity of the crank-pin. The point B is obtained by drawing NO and then B′R perpendicular to S′A′ and RB perpendicular to SA.

To prove the accuracy of this method the infinitely small displacements of A and A′ may be obtained by moving the point N in the arc of a circle NN′ and in drawing NS and NS′, in passing to the limits NN′ becomes a tangent to the circle. Draw N′H parallel to N′S and N′H′ parallel to NS′, the lengths NH and NH′ are proportional to the velocities of the points A and A′. It is easily seen that the

figures ROB is similar to N′ NH′ because the corresponding sides are perpendicular. The lengths OB′ and OB are then also proportional to the velocities of the points A and A′. Now the velocity of the point A′ is OB′ and that of A is OB.

In like manner the velocities of the piston for other positions of the stroke, as Figure 10, M′ M″, etc., are determined giving the points P′ P″, etc. To get the mean velocity (v) of the piston during that portion of the stroke in which the discharge valve is open, it is only necessary to obtain the area of C′ PM and then dividing by the length C′M, thus giving the mean height h.

Then will

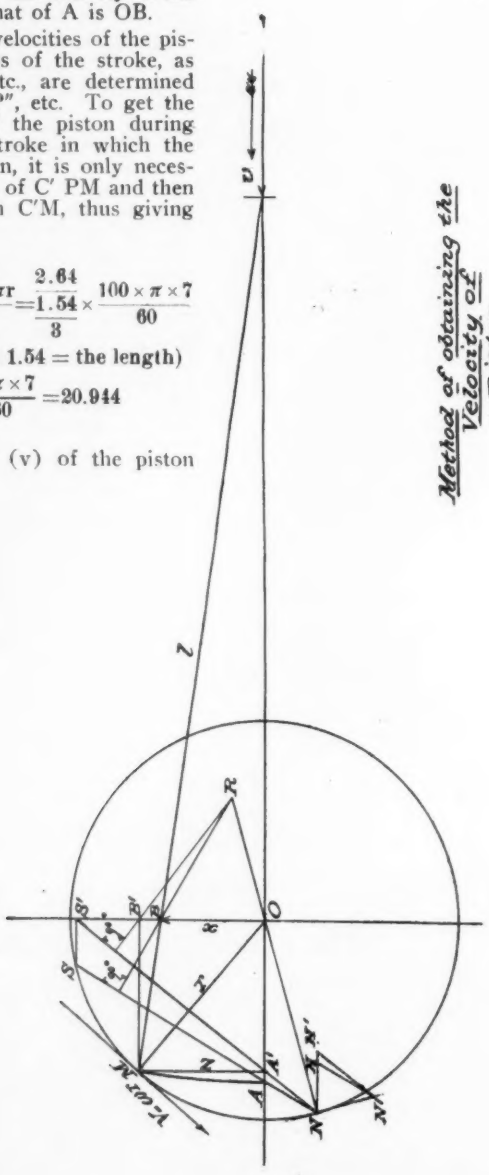
$$\frac{\text{area of MPC'}}{\text{length}} \times \frac{100 \times 2\pi r}{60} = \frac{2.64}{1.54} \times \frac{100 \times \pi \times 7}{60}$$

(where 2.64 = area and 1.54 = the length)

$$= \frac{2.64 \times 100 \times \pi \times 7}{1.54 \times 3 \times 60} = 20.944$$

in inches per second.

be the mean velocity (v) of the piston while valve is open.



Method of obtaining the Velocity of Piston

Fig. 11.

Next to find mean lift of valve (h), simply divide the area of MSC' by the length MC', which gives 0.16 inches as the average lift of valve.

Referring again to sketch of valve, the velocity V of air through valve in inches per second is, therefore,

$$V = cv/h$$

where c = constant $= \pi D^2/4 \div \pi d \cos 45°$

$= 49 \times \sqrt{2}/4 \times 1.531$

$= 11.31$

therefore $V = 11.31 \times 20.944/0.16$

$= 1480$ inches per minute.

$= 123.3$ feet per minute.

Figure 12 shows a similar diagram for a speed of 132 revolutions per minute, and an absolute pressure in the receiver of 91.45 pounds per square inch. This pressure being very nearly the same as in the previous case.

This may have been due in part to the better action of the valves. As no tests were made on the valves at 180 revolutions per minute, nothing can be stated as to whether or not the springs were suited for this speed.

As before $c = 11.31$

$v = 22.3/1.41/3 \times 132 \times \pi \times 7/60$

$= 230 \times 132 \times \pi \times 7/1.41 \times 3 \times 60$

$= 26.31$ inches per second.

$h = 0.21/0.76$

$= 0.2763$ inches.

therefore $V = 26.31 \times 11.31/0.2763$

$= 1076.9$ inches per second.

$= 89.7$ feet per second.

Thus the mean velocity through the valves is less for 132 than for 100 revolutions per minute. This would lead to the conclusion that the spring in the discharge valve was too heavy for 100 revolutions per minute, and was better suited for 132 revolutions per minute. This can also be seen from the figures themselves, as at 132 revolutions per minute the valve retains its maximum opening much longer than for 100 revolutions per minute. As was previously ascertained from the general tests, "The best results were obtained at 132 revolutions per minute."

Although possibly somewhat short, the above should present a more clear idea as to the method which might advantageously be employed in the study of such types of machines.

The advantage in determining the actual position and velocity of the piston for any

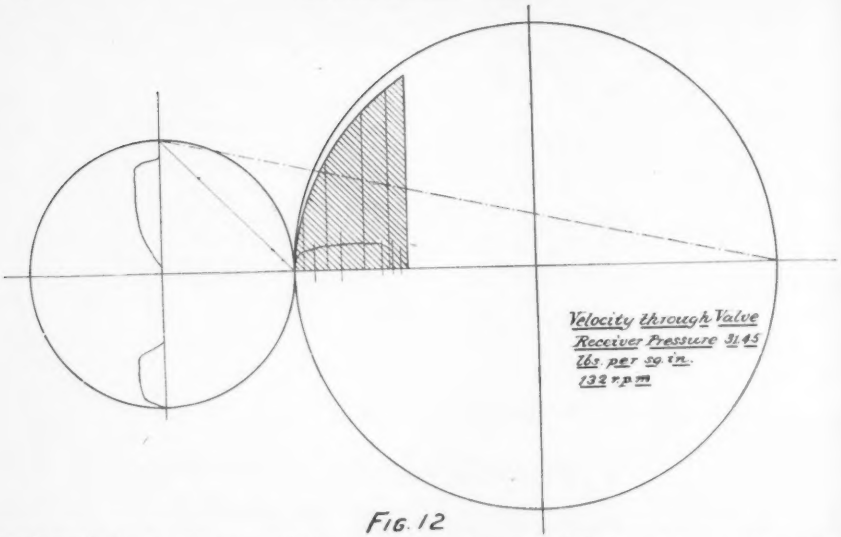


FIG. 12

crank angle by the above methods is that no long beam compass is required and many accurate results may be obtained by drawing a large crank circle with ordinary compasses.

ARTHUR P. HALL, S. B.

Vim Air Packings.

Notwithstanding the fact that rubber, canvas, compressed fibre and other materials have been repeatedly offered as a substitute for leather in the industrial arts, the fact remains that these products have only been partially successful in special cases. The leather has been found tougher and more satisfactory for general use than any of the substitutes. When, however, E. F. Houghton & Co., Philadelphia, Chicago and Detroit, announced to the users of compressed air that they were manufacturing, not a substitute, but rather a superior quality of leather for the purpose of making air packings, it was received with interest.

Upon invitation from the manufacturers, a representative of COMPRESSED AIR made several tests of the product with regard to its adaptability to air packings. The material is designated by the trade mark "Vim Mechanical Leather," and is adapted practically to all mechanical uses.

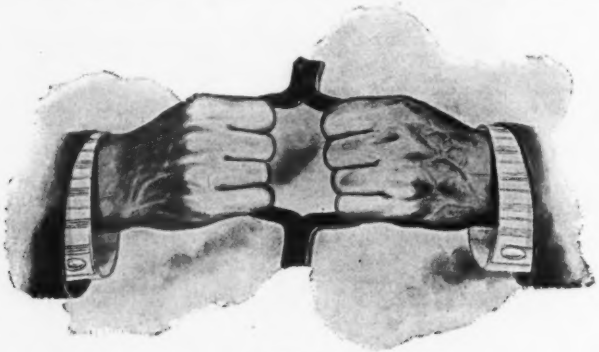


FIGURE I.

They start, of course, with a green hide. In the manufacture of oak bark tan leather the hides are converted into fibre by a continuous bath for months in tannic acid. Houghton & Company's representative claims that, in order to have the tannic acid reach the centre of the oak tan hide and thoroughly tan it, the acid overtans the exterior of the hide, and that, under microscopic examination, an oak tan hide will show shorter fibres on the surface and is strongest at its centre.

While we did not verify this, several comparisons were made between the oak leather which is in general use and the Vim leather. A test of the strength of the green or hair side of the two leathers showed a remarkable difference which was greatly in favor of the Vim leather. Another experiment tried was to discover the power required to tear pieces of the two kinds of leather, as shown in Figure 1. It was a comparatively easy matter to tear a piece of oak leather with the hands.

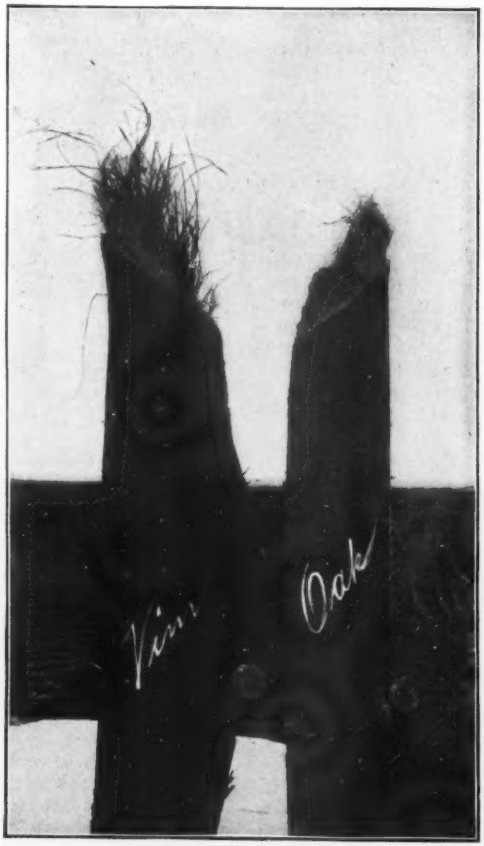


FIGURE 2.

The Vim leather could not be torn in that fashion, but required a greater amount of force to separate the fibres. After tearing pieces of Vim leather and oak leather, a photograph was made, which is shown in Figure 11, illustrating the difference in the manufacture of fibres.

Houghton & Co. claim that, with the oak

process the pores of the hide open and absorb the fine particles of pigment from the bark tan, coloring the hide to what is generally known as a tan color. The natural color of the hide in the absence of any pigment is a green or grey. They further claim that these particles of bark swell or puff the leather, hinder the fibres from coming into close contact, and fill the pores so that they cannot take as much lubricant as would be practical were the oak pigments not in the pores. They declare that the process by which they tan the leather enables them to use 100-pound hide where other parties making packings use a 60 to 65 pound hide. But, notwithstanding the increase in cubical dimensions of the hide with which to commence operations, owing to the absence of any puffing in the pores they succeed in producing a more compact leather, combining more actual fibres to the cubic inch, than it is possible to produce by any other process. This is, they claim, made possible by producing the finished leather by oxidation instead of the action of acid, giving a leather with open pores, free to receive whatever lubricant is necessary to adapt it for the particular purposes for which it is intended.

It has been a well-known fact for years that leather will not stand the action of hot water, yet they demonstrate that hot water has practically no effect on Vim leather.

On the ground that the length, strength and closeness of contact of fibres govern the strength of all fibres, Houghton & Co. reason that their leather has greater strength. They contend that there is more leather fibre per cubic inch in their backing owing to the absence of oak bark particles in the pores, and that these fibres are longer and stronger and in closer contact.

Houghton & Co. express strong faith in their packings, selling them with a broad guarantee of twice the wear of ordinary leather, and they assure us that they can instance many cases where from three to thirty times the wear was secured. The first cost of the Vim packing is about that asked for the best oak packings.

It is scarcely necessary to emphasize the importance of individual investigation on the part of users of compressed air into the true merits of this packing, because it means a long stride in economy.

Comparison of Costs of Compressing Air with Steam and Electricity at Rossland, British Columbia.*

Compressed air has become so generally used in connection with mining operations, and so well recognized as the most useful and economical power, with its unlimited range of uses and special adaptability to underground work, that an introductory to this paper on the subject would be superfluous to mining engineers.

The comparative economy of prime movers for air compressing engines is, however, of great interest to all, and a subject on which any engineer can read with interest. This is particularly the case with engineers practicing in British Columbia, where a large number of the mining problems include the extraction and reduction of large bodies of low-grade ores and the consequent necessity for a thorough study of economical methods for mechanical handling.

The general mobility of compressed air as a power allows a wide range of generators, or prime movers, but we can, in nearly all cases, rely upon having to adopt primarily one of two sources of power, viz., water or heat.

Water, the first of these, can, as we know, be used in many ways, each terminating finally at the mine as compressed air ready for service. The initial water-power may come from one or more sources, situate either at the mine or many miles distant, and can be used either as a directly connected unit of power for the compression of air or as a prime mover for some intermediary power.

British Columbia has been fortunately blessed with magnificent water-power, more particularly in the Kooteneys. In many cases these water-powers are situated close to the mines; in others, as at Rossland, they are several miles away.

Distances over which power can be economically transmitted by electricity are yearly becoming greater, until it seems that distance is no longer an obstacle, and it has become simply a question of capital investment to successfully transmit the power generated by water almost any distance.

Heat, the second great source of power for the generation of compressed air, has

* Written by William Thompson for the *Mining Reporter*.

been successfully used as steam for many years, even in places which seemed to be utterly inaccessible either for the erection of the necessary machinery or the securing of fuel after the machinery had been installed and made ready for operation. So accustomed have we become to surmounting difficulties of this kind that we are apt to look with suspicion upon any suggestion to utilize distant water powers, preferring to resort to steam as being the power we best understand and one which has been successfully installed and economically operated under very adverse circumstances.

British Columbia has been abundantly provided with fuel; in fact, we can say the supply of coal is practically unlimited. Enterprising capitalists, year after year, extend railways between the coal fields and the consumers, so that no producing or promising mining district has long to wait for an unlimited supply of this fuel. The mines at Rossland are exceptionally favored in this respect, all the leading mines having access to two lines of railways, and through them the coal fields of both British Columbia and the State of Washington.

Rossland is also favored by having the immense water power at Bonnington Falls, less than 40 miles distant, immediately available. The enterprises of Sir Charles Ross and associates in the West Kootenay Power and Light Company have rendered this available for any service at each mine, as a competitor of the steam power, which mine managers would otherwise be compelled to adopt.

The question of the selection of power supply to be made by mine managers at Rossland is almost entirely removed from chance, and may be based on ascertained facts. Railways being at hand for the transportation of any kind of machinery, reasonably cheap fuel in quantities required is assured, and electric power for any size machinery or service is available. Therefore, the problem simply resolves itself into "WHICH OF THESE POWERS WILL GIVE THE BEST SERVICE IN OPERATING THE MACHINERY USED IN CONNECTION WITH MINING OPERATIONS?"

The same privielge applies to nearly every other mining district in Southern British Columbia; therefore, the writer feels that the results obtained in the air compressing plants at Rossland will be of special interest to mining engineers.

The steam and electric plants described below were modeled on the design and erected under the personal supervision of Mr. Bernard McDonald, then general manager of the Le Roi and Nickel Plate mines, assisted by the writer. The steam plant was erected for the Le Roi Mining Company (Ltd.) and consists of the following, viz.:

Boiler Plants.

Two 250 H. P. Heine Safert water tube boilers, arranged to burn coal as fuel. These were intended to generate steam to run the air compressors and were set so as to work, if desirable, in connection with the nine 125 H. P. steel shell return tubular boilers, designed to operate the hoisting and surface plants. These boilers are arranged to be interchangeable to either service.

During the test the water tube boilers were used at a gauge pressure of 150 pounds per square inch, using Crows' Nest coal as fuel, which cost, laid down in front of the boilers, $5.55 per ton of 2,000 pounds.

Air Compressing Plant.

The steam-driven plant consisted of two compound condensing Corliss valve engines, direct connected to two stage air cylinders, equipped with intermediate cooling devices, each machine having a rated capacity of 4,000 cubic feet of free air per minute, or a combined capacity of 8,000 cubic feet of free air per minute at sea level. A more detailed description of these engines would be as follows:

	Engine No. 1.	Engine No. 2.
Diameter high pressure steam cylinder	22 in.	22 in.
Diameter low pressure steam cylinder	36 in.	36 in.
Diameter high pressure air cylinder	22 in.	22 in.
Diameter low pressure air cylinder	36 in.	38 in.
Length of stroke	48 in.	48 in.

Intercoolers, horizontal multitubular type; condensers, independent jet.

The Electrically Driven Air Compressing Plant.

This plant was erected by the Rossland Great Western Mines (Ltd.), and was originally intended to be operated in connection with the steam plant previously described, the intention being to supply

power from a central station to four mines owned by different companies. This arrangement would have given each mine power at the lowest possible cost and have insured continuous operations, by reason of the compressing plant being arranged in separate units. Each company would pay its share of operation, maintenance of plant, *pro rata* to its consumption of air.

When it was found necessary to erect the third unit to the compressing plant unforeseen difficulties presented themselves in the shape of shortage of water for condensing and cooling purposes. On examination it was found that a satisfactory supply could not be secured without heavy capital expenditures for erection of flumes, etc., to convey the water to where it was required for use.

It was, however, found that a supply of water barely sufficient for the intercoolers and waterjackets was available about three-fourths of a mile distant from the steam plant. This supply was so located that it must either be pumped or else the plant located at this distance away from the main steam plant. By conserving the water supply, cooling and reusing it was decided a sufficient supply of water for the jackets and intercoolers could be secured.

The result obtained from the steam plant had proven so satisfactory that it was considered questionable if any electric plant could be installed that could successfully compete with steam, even when running non-condensing, unless very favorable rates for power could be secured. After negotiations with the power company it was decided to erect an electrically driven plant, a short description of which is as follows:

Electrical Equipment.

Three-phase, S. K. C., synchronous motor designed for 2,200 volts, with a rated capacity of 660 K. W., equivalent to about 825 H. P. The motor is provided with a separate starting motor, mounted on the main frame, exciter and Italian marble switchboard, on which all operating switches and instruments are mounted.

There is a 54-inch Frisbee clutch set intermediate between the driving pulley and the motor. The motor is of a four-bearing type, fitted with self-aligning and self-oiling sleeves. The entire machine is mounted upon a solid cast-iron base set upon massive concrete foundations. The driving pulley is 60 inches in diameter, grooved for twenty-two 1½-inch ropes, and runs at 270 revolutions per minute.

The three compressors were built by the Canadian Rand Drill Company, of Sherbrooke, Quebec, and are especially designed for constant service.

The electrical equipment is also entirely of Canadian manufacture, the entire apparatus being manufactured by the Royal Electric Company, of Montreal, who are the Canadian manufacturers of the S. K. C. apparatus.

All tests were conducted under the personal supervision of the writer, and extreme care was taken to arrive at actual facts. Indicator diagrams were taken off both the steam and air cylinders every half hour and the results tabulated. Coal consumed was weighed and all other supplies, such as waste, oil, etc., charged as used.

Readings were also taken and recorded by means of a delicately adjusted kilowatt meter, connected to the primary mains, of the amount of electric power used. The test extended over a period of thirty days, without interruption, both plants being run under exactly similar conditions as to air pressure.

Each of the plants tested being modern and representative of their respective types, gave an opportunity for a comparative test that rarely falls to the lot of an individual engineer under such favorable conditions as to work being performed, and for this reason is the more valuable as data for basing calculations as to problems of power.

The average results of the thirty days' test is recorded in Tables I., II., III., IV. and V., following:

Table I.—Work Performed by Steam Plant.

Average indicated horse power at steam cylinders of the combined machines	730
Free air compressed per minute from atmospheric pressure to 95 lbs. per sq. in., cu. ft.	5,432
Free air compressed per hour, cu. ft.	325,920
Average horse power required at steam cylinders to compress 100 cu. ft. of air per minute to gauge pressure	13.4
Pounds of coal consumed during test.	1,038,000
Pounds of coal consumed per day of 24 hours	36,400
Average pounds of coal consumed per horse power per hour during test.	1.9

TABLE II.—WORK PERFORMED BY ELECTRIC PLANT.

Average horse power registered at switchboard	540
Free air compressed per minute from atmospheric pressure to 95 lbs. gauge pressure, cu. ft.	3,319
Free air compressed per hour, cu. ft.	199,140
Average horse power required at motor to compress 100 cu. ft. of free air per minute to 95 lbs. gauge pressure	16.3

TABLE III.—COST OF OPERATING STEAM PLANT.

Total cost of fuel consumed during test	$2,880.45	
Total cost of wages for employees	710.00	
Total cost of oils, waste, etc.	147.30	
Total cost for 30 days, exclusive of maintenance and depreciation		$3,737.75
Cost per H. P. per month for fuel	$3.96	
Cost per H. P. per month for oil, etc.	.20	
Cost per H. P. per month for wages	.97	
		5.15
Cost per H. P. per annum		61.56
Cost for each 100,000 cu. ft. of free air compressed		1.56
Cost per drill shift		1.25

Note.—Eighty thousand cubic feet taken as the average consumption per shift of one 3¼-inch drill.

TABLE IV.—COST OF OPERATING ELECTRIC PLANT.

Cost of current for thirty days	$1,744.26	
Cost of employees' wages.	270.00	
Cost of oils, waste, etc...	73.00	
Total cost for 30 days, exclusive of maintenance and depreciation		$2,087.86
Average cost per H. P. per month...		3.87
Average cost per H. P. per annum..		46.44
Cost for each 100,000 cu. ft. of free air compressed		1.46
Cost per drill shift		1.17

Note.—Eighty thousand cubic feet taken as the average consumption per shift of one 3¼-inch drill.

TABLE V.

Showing comparative results between the two types of compressors, based on each 100,000 cubic feet of air compressed from atmospheric pressure to ninety-five pounds, receiver pressure.

Cost for each 100,000 cu. ft. of free air, compressed by steam plant (see Table III.)	$1.56
Cost for each 100,000 cu. ft. of free air compressed by electric plant (see Table IV.)	1.46

Result, saving by electricity over steam, 6.4 per cent.

TABLE VI.

	Degrees Fahr.
Temperature of cooling water at inlet of intercooler	42
Temperature of cooling water at outlet of intercooler	50
Rise in temperature of cooling water while passing through intercooler	8
Temperature of air at outlet of low-pressure cylinder and before passing through intercooler	196
Temperature of air at outlet of high-pressure cylinder, after passing through intercooler	54
Reduction in temperature of air after passing through intercooler	142

In conclusion, permit me to state that this paper has not been prepared with the idea of recording the performance of these two plants except in so far as comparisons can be drawn between the relative efficiency of the two systems, so that engineers, knowing local conditions, can have some record of actual performance before them.

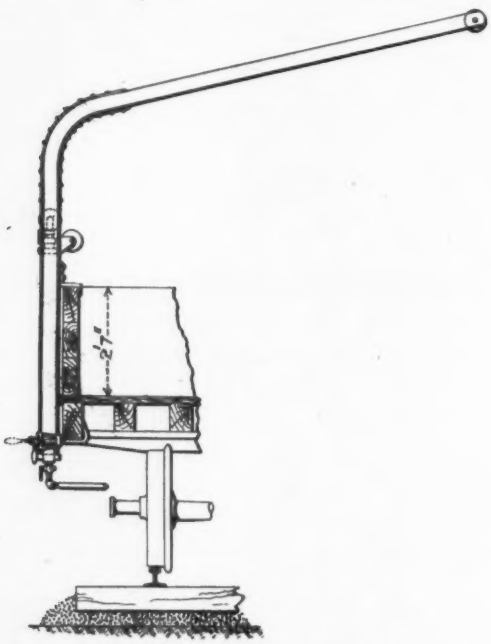
The saving shown in Table V. would be affected adversely if the electric plant was operated singly and the entire air compressed was not used. For the reason that electrically driven compressors must be operated at constant speed, and loss of air at safety valve would be considerably increased over the same loss at steam plant, which could, of course, be run at the speed required to compress the amount of air actually required. This loss would, however, be slightly offset by the increased cost per horse-power by working the steam compressors on underload. I wish to draw special attention to the noteworthy results obtained from the system of intercooling used on the compressors tested.

In Table I. it is shown that the steam plant required 13.4 H. P. to compress 100 cubic feet of air to 95 pounds gauge pressure per minute. The best power factor recorded that has come under the writer's notice for doing the same amount of work by a two-stage compressor is 14.5 H. P., which shows a saving of 8 per cent. resulting from the use of specially designed intercoolers, for which the manufacturers are entitled to receive the credit.

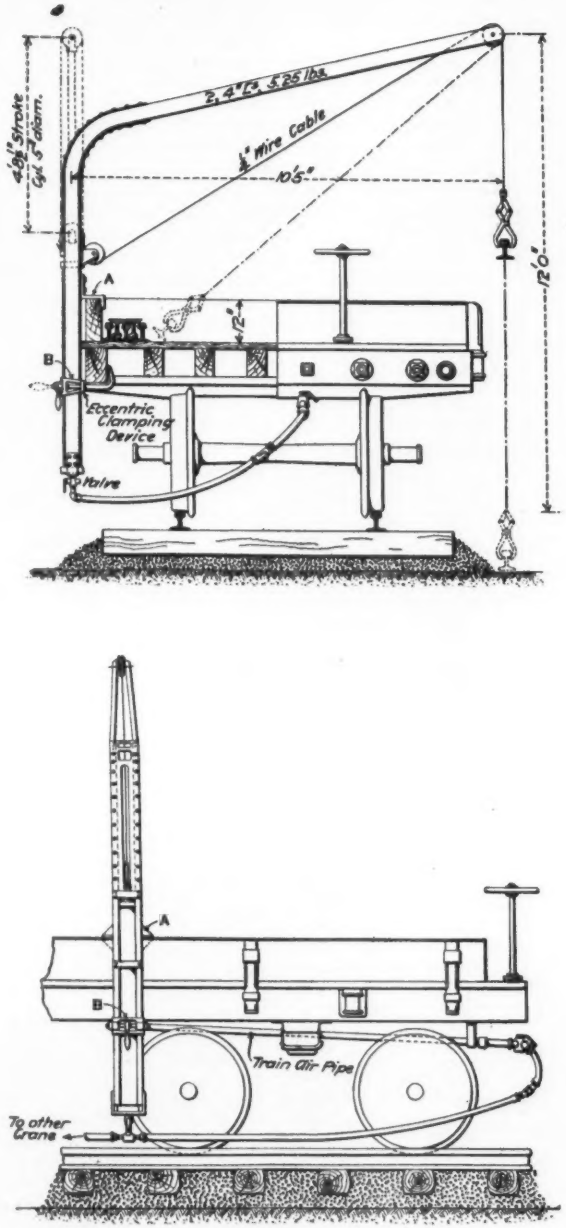
How this result is obtained can be best understood by reproducing the average of a number of tests made on the efficiency of the intercooler during the progress of the power test. The results of these tests are shown in Table VI.

A Pneumatic Rail Unloader.

The accompanying drawings show a simple device for depositing rails from cars alongside the track, using air from the train line as power. It was designed by the Pennsylvania Railroad in October, 1901, but for some reason was never built, although it could be easily and cheaply put together and mounted on any low side gondola such as is usually used in carrying rails. It consists essentially of two jib cranes clamped on the side of the car about 5 feet from each end, each crane having a 5-inch air cylinder with a 4-foot 8½-inch stroke, connected to the train line. The cranes are made of two 4-inch, 2-25-pound channels, bent as shown and spaced far enough apart between the vertical portions to admit the air cylinder. They are reinforced at the bend with top and bottom cover-plates, slotted to allow the piston and cable sheave to move up to the dotted position shown in the drawing. A ¼-inch wire cable is used, one end being fastened to the crane, the cable passing over the sheave on the end of the piston, down under a fixed sheave on the inside of the jib and out and over the sheave on the end of the jib. A pair of grapple hooks is fastened to the other end of the cable. The cranes are attached to the side of the car by a broad fixed bracket or bent knee, A, which fits over the top of the side boards and by a movable eccentric clamp, B, which clamps to the inside face of the side sill. This clamp may be moved up and down on the vertical portion of the jib to accommodate any height of side of the car up to 2 feet 7 inches. Air is taken from the train line coupling through a flexible connection leading back to a three-way cock in the bottom of the cylinder of the first crane. A pipe or hose from this cock leads back to the other cylinder on the car and the one valve controls the movement of both pistons simultaneously. With a 9½-inch by 10-inch air pump running at



A PNEUMATIC RAIL UNLOADER—END VIEW.



A PNEUMATIC RAIL UNLOADER—SIDE AND END VIEW.

25 strokes per minute, sufficient air can be supplied to keep both cranes in continuous operation.

The rails can be unloaded by four men, two on the car and two on the ground. One of the men on the car assists in hooking the rails and also operates the cylinders by a reach rod from the three-way shut-off cock which is brought up above the side to a convenient position within easy reach. When one car of rails is unloaded, both cranes can be easily and quickly shifted to the next car in the train.

We are indebted to Mr. A. P. Sharp, Chief Draughtsman, Motive Power Department, P. R. R., Williamsport, Pa., for the drawings.—*Railroad Gazette.*

Air Brakes in City Service.*

Something has recently been written about the economy of air brakes and the general advisability of their use in city service. The latter question has been settled as regards double-truck cars in nearly all the large cities in the country in favor of the air brake.

Several questions confront the management when considering the use of air: Are the cars worth the additional expense? for air brakes are undoubtedly expensive. What advantages will they gain by their use? What will be the cost of maintenance?

The first question is not very difficult to answer. All large systems are continually buying new cars, and it is needless to say that the oldest cars are probably not worth the expense. As to the second question, there seem to be three advantages gained over the hand brake, viz.: The ability to maintain a faster schedule; the decrease in accidents due to the emergency stop, and the slight economy in power consumed by the car.

Several competitive tests against the hand-braked car have proved this, but as the saving is so slight it is only necessary to convince the management that more power is not being used to drive the independent motor compressor than was used before.

In regard to the ability to maintain a faster schedule, in city as well as interurban service, it is well known that acceleration plays a most important part, but acceleration is both positive and negative, and they are equally important. The time has come when the amount of acceleration, either positive or negative, must be limited by the comfort of the passengers. This renders necessary a uniformly accelerated start and stop as near as it is possible to secure it.

The modern car controller aims to make the positive acceleration as uniform as possible, though, to a large extent, it is still dependent upon the skill of the motorman, as is also the negative acceleration in stopping with the air brake. An acceleration both positive and negative of two miles per hour per second can be obtained in a modern car equipped with air brakes without discomfort if fairly uniform. The resulting increase in schedule speed even in city service under the above conditions is remarkable.

The emergency stop with the air-braked car, while it may nearly cause the passengers to "change seats," has undoubtedly been the means of preventing some loss of life as well as the saving of thousands of dollars in damage to equipment. Almost every road which has used air brakes for the past few years can testify to the truth of this statement, and many cases have occurred under the writer's personal observation.

The cost of maintaining an air-brake equipment varies in about the same proportion as the cost of maintaining the motive power of the car. It depends entirely upon the existing conditions on the different roads.

These conditions mean not only the physical characteristics of the road as regards grades, etc., but also on the kind of care and inspection the equipment receives from those immediately in charge. In this last condition lies the whole secret of the cost of maintenance. Rigid inspection daily of the air-brake equipment is as necessary as the inspection of the motors and controllers.

In nine cases out of ten the failure of an air brake is due to such trifles as a wornout carbon brush in the motor compressor or some disarrangement of the connections to the automatic governor, which can be repaired in less than five minutes, and are nearly always due to careless inspection, or, more often, to no inspection at all. The result is that the cost of main-

*Written by Edward C. Boynton for the *Street Railway Journal.*

tenance on different roads varies to an astonishing degree; so also does the cost of maintaining the motive power.

Instances are on record where air brakes have been in service for upward of four years and nothing done except to keep bearings oiled and brushes in place. The cost of maintenance in the above case is almost negligible for those four years. Other cases are known where bearings soon went down for want of oil, and other troubles arose for lack of attention, and the cost was high.

Another road will adopt air whistles without thinking that the whistle uses more air than the brake. The increased use of air will naturally increase the cost of maintenance. One large system using many air-brake equipments kept a careful record of repairs and found that it cost approximately 30 cents per month per car, or about 1 cent per day. This is a fair average record, but of course did not include brake shoes.

Air Compressors in the Operation of the New York Subway.

The daily traffic service of the New York Subway contemplates the operation of two tracks carrying local trains at one-minute intervals and two more tracks with eight-car express trains at two-minute intervals. It will be appreciated that the safe handling of trains in such number and frequency offered problems in signal work almost unparalleled in railway history. A system has been worked out and applied which practically guarantees the safety of the traveling public. This is a development of the well-known electro-pneumatic switch and signal system used for years with such success on the great railways of the country. In the operation of this system electricity and compressed air have joined forces; electricity being, as it were, the nerves and compressed air the muscles of the system. Electricity is the directing force, compressed air the actuating power. The reliability of any switch and signal system depends upon the reliability of its sources of power. The electrical appliances offer nothing of decided novelty; they are standard. But the air compressors are unique in design and are worthy of a brief description.

The machines were built by the Ingersoll-Sergeant Drill Company, of New York, and are a modification of standard type known as Class "EC." They are two-stage machines with horizontal intercooler, fitted with the Ingersoll-Sergeant piston inlet valve and designed throughout for maximum economy, simplicity and reliability. Nine compressor units have been installed and three more are under construction. Each compressor is connected by a Morse silent chain to a 35 H. P. Westinghouse direct-current motor taking current from the lines at from 400 to 700 volts. Motor and compressor unite on a solid sub-base. At rated speed of 120 R. P. M. each unit has a capacity of 215 cubic feet of free air per minute compressed to 80 pounds pressure. The compressors are automatically controlled and regulated by the air pressure. Working pressure on the system is maintained constant within five pounds of the fixed standard. When receiver pressure falls below normal a combination of electrical circuits operates to bring the compressor to speed with no load, then cut out the starting resistance and throw on the load. When normal pressure is reached on the system, the machine is unloaded and the motor cut out. Arrangement is also made whereby the starting and stopping of the unit also automatically starts and stops the flow of intercooling water and lubricating oils. The performance of these devices is thoroughly satisfactory.

Compressed air from these machines, which are located in sub-stations along the subway, is distributed through two-inch pipe lines running the length of the system and operates various signal mechanisms, pneumatic switches, automatic train stops, displacement pumps, etc. The installation of these electrically-driven air compressors, with their automatic control and regulation, marks a great step forward in switch and signal work. Their performance under the extremely arduous service conditions in the subway is an interesting commentary on the "dependable" quality of the modern air compressor.

Raising Water with Air Lift.*

On page 5 of the June number of *The National Engineer* there appeared an article on the delivery of water with an

* Written for *The National Engineer* by Mr. W. E. Crane.

FIG. 1

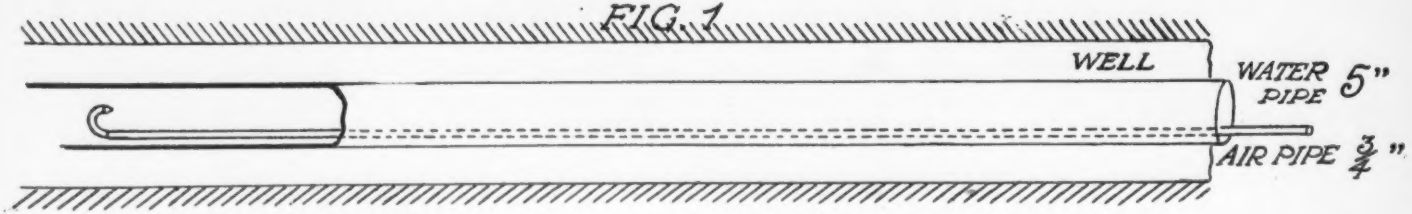
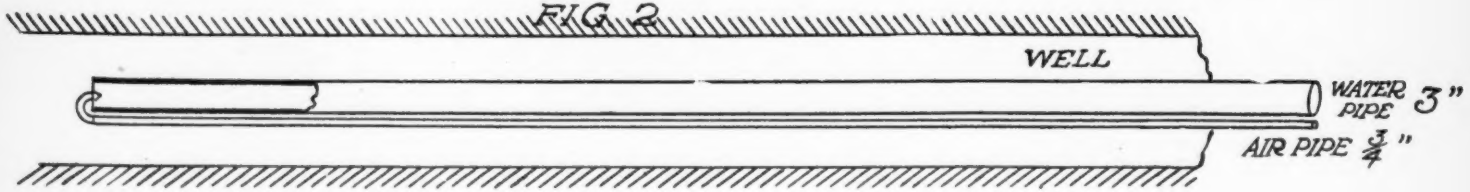


FIG. 2



air lift. If the article had been illustrated with sketches, it would have added interest. The article did not state in what shape the 1¼-inch air pipe was left for the outflow of air at the end.

I recall a case where wells were driven in the ground, where one of them was 1,000 feet deep and others in the same system were not deeper than 650 feet.

These wells were capped with a tee and a ¾-inch air pipe let down for about 250 feet. The pipe was closed at the lower end, and near this end on either side of the pipe a long slit was cut, the slits having an area equal to the area of a ¾-inch pipe.

This form required too much air, and experiments were made to determine how small an amount of air was necessary to get the maximum amount of water.

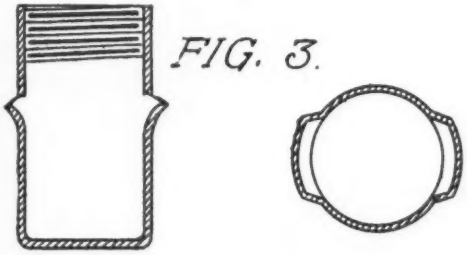


FIG. 3.

A brass head like figure 3 was made with a slot running across so that the air should be delivered upwards, and a tool made with which these slots could be enlarged. After repeated trials it was determined that an area of .04 of a square inch, or less than the area of a ¼-inch nozzle, would furnish all the air needed, and the wells were all fitted with this device. The water in one of these wells came to the surface, and in the others to within 40 feet.

In another case a well was put down having a 10-inch pipe to rock, which was found at a depth of 90 feet, and the well continued down through the rock for 75 feet, when water was found.

An air pipe was lowered into the well, but it would not elevate the water. A 5-inch pipe was then put down as in figure 1. In both cases a return bend was put on and a nozzle having a ¼-inch opening looking upward. This latter arrangement elevated the water very well. The 5-inch pipe reached 140 feet from the surface and the air pipe 5 feet less.

In another well a 3-inch pipe was put down together with a 1-inch air pipe, the latter terminating in a ¼-inch nozzle,

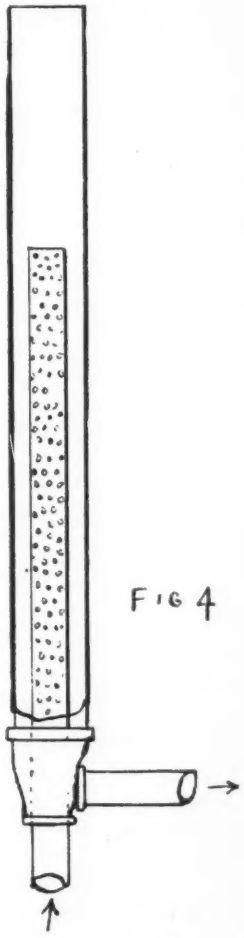


FIG 4

and going down on outside of 3-inch pipe, and turning up at bottom of same as in figure 2, making a far better plan.

In one case, a man using an air lift put down a 1-inch air pipe with full size opening, and found that the air com-

pressor could not supply the demand for air. It was impossible to convince him that a ¼-inch pipe was sufficiently large, so he compromised and used a ½-inch pipe, securing as much water as when using the 1-inch pipe, and reducing the consumption of air sufficiently to enable the air compressor to easily meet all demands made on it to operate the lift.

Where the water from a well is carried in a horizontal direction, it will require less power and smaller pipe if the air is separated from the water.

This can be done with an arrangement as shown in figure 4.

If the pipe in the well is 3 or 4 inches, put on an 8 by 3 by 4-inch tee. Then put in a perforated pipe so as to extend the pipe from the well 6 feet beyond the tee, with the end of the pipe plugged. Make the 8-inch pipe 10 feet long and open at the top. For a 4-inch pipe, the outside might be 10 inches. On the 4-inch pipe put the horizontal pipe. The elevation of the tee is governed by the height necessary to give sufficient head to the horizontal pipe. The holes allow the water and air to flow out in all directions, then separating and the air going out at the top, while the water flows out at the bottom. Where the air is not separated the horizontal pipe must be large and considerable power expended.

The Compressor Stuffing Box.*

The horizontal double-acting compressor with its many advantages is steadily gaining in the favor of the manufacturer as well as the user. This horizontal machine requires only half of the stress on connecting rod, bearings and crank, to which the same parts are subjected in the case of single-acting compressors of the same capacity. Single-acting machines are usually of the vertical type, which makes it necessary for their working parts to be many feet above the floor; in consequence thereof, these parts are removed from a convenient observation by the operator and are as a general rule not examined as frequently as is desirable in the interest of wear and tear.

A horizontal compressor, on the other hand, is always under the eye of the engineer. A glance at the machine shows the condition of all parts with reference to their proper working order, as well as in regard to lubrication.

In contrast with all these advantages there was, in the early days of double-acting compressors, one disadvantage, namely, the stuffing box.

The stuffing box is one of the most important parts of the machine. It must prevent the escape of the charge handled by the compressor and it must be tight against any leakage of atmospheric air,

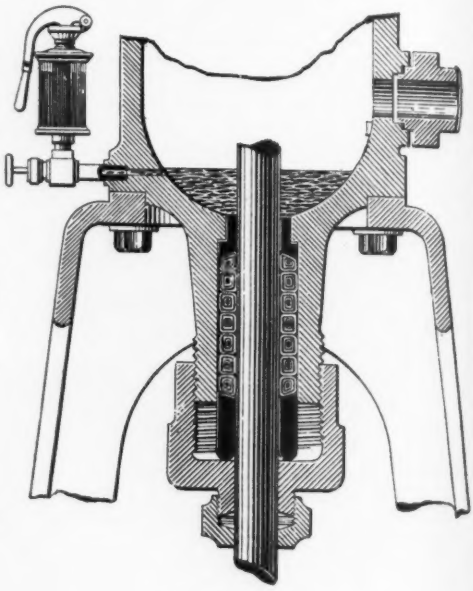


FIGURE I.

water or steam into the same without creating undue friction on the piston rod and its consequent heating.

A practical stuffing box affects the economy of the machine very considerably, not only as far as the prevention of gas leakage is concerned, but also with reference to the use of power necessary to overcome the friction of the packing. It follows that very much depends upon the thorough fitness of this part for the purpose.

In single-acting vertical compressors it is only necessary to maintain a little

*By J. C Goosmann, M. E., in the *Cold Storage nd Ice Trade Journal*. First of series of papers.

oil in the bottom of the cylinder around the piston rod to prevent the passage of gas through the packing, as shown in Figure 1. This oil is under the pressure by which the gas is forced through the inlet or suction valves into the cylinder, which is from 15 to 20 pounds at the average. In double-acting compressors, however, the piston rod and its packing are subjected to the full forward stroke. There can be no oil pocket around the piston rod inside of the cylinder owing to the horizontal position of the machine, and it was therefore necessary to devise other means to prevent the escape of the charge under these increased difficulties.

ficiently to prevent the leakage of gas between the packing rings and the stuffing box bore at line *e*. Gland, *d*, is provided with a second oil chamber, *f*, and a small oil pump, which is operated from the shaft of the machine by means of a cord-belt, forces the oil through the gland and back into the oil basin, *g*, as shown in Figure 3. The pump, with oil basin attached, is mounted on the frame of the compressor directly below the stuffing box, and any oil leaking through the outer end of the same drips into it. A small part of the oil is taken along on every head-stroke of the piston and on its passage over the lantern supplies any deficiency of oil in same and the rest

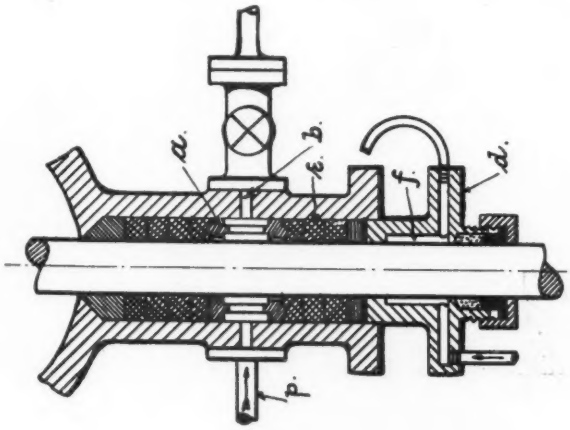


FIGURE 2.

Prof. Linde solved the problem successfully by introducing a lantern with oil chamber into the centre of the stuffing box, as shown in Figure 2. This lantern, *a*, consists of a metallic double ring, which is bored out large enough to clear the piston rod. The chamber is placed between ordinary cotton packing rings and its inner space is kept filled with oil. A small hole, *b*, bored through the neck of the compressor, connects the oil chamber with the suction side of the system so that the oil is kept continually under the suction pressure. The bottom ring, *c*, consists of white metal, and the gland, *d*, is gently drawn up so as to compress the various packing rings sufdrops into the cylinder, where it is used for lubricating purposes. Pipe, *p*, connects the stuffing box lantern with the lower part of the oil trap, and as this passage is always open the oil is forced into the oil cylinder by the pressure of the gas in the oil chamber. Prof. Linde's construction uses only the suction pressure of the gas for this purpose, but another modification of his principle obtains the oil from the high-pressure oil trap, which is interposed between the discharge valves of the compressor and the condenser, so that the oil in this modified stuffing box is kept under the compression pressure of the system.

The Fred. W. Wolf Co., Chicago, Ill., manufacturers of the "Wolf-Linde" machine, uses a special rubber ring in place of the cotton packing rings introduced by Linde. After considerable experimenting this company found a rubber composition, which withstands the action of the oil successfully, and which absolutely prevents the leakage of ammonia, while at the same time minimizing the friction. Figure 4 shows a section of the improved "Wolf-Linde" stuffing box.

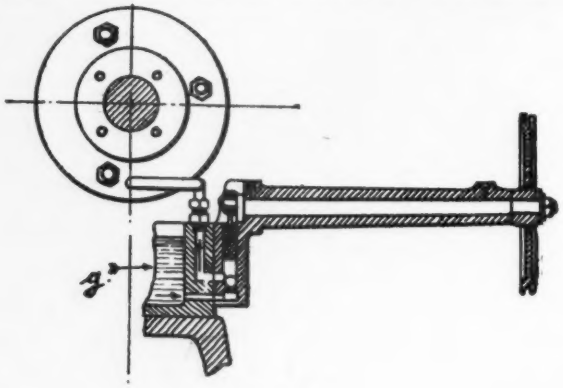


FIGURE 3.

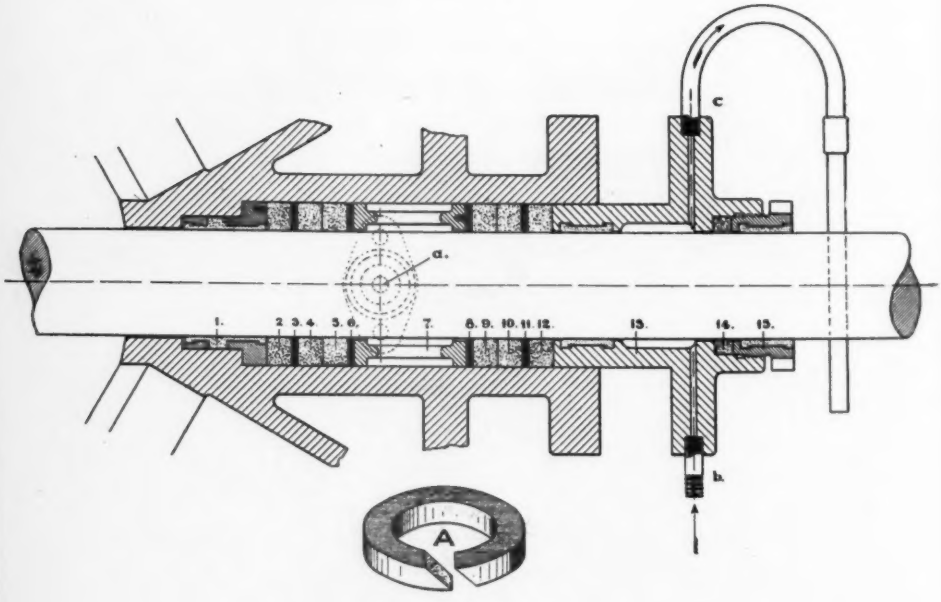


FIGURE 4.

Numbers 2, 4, 5, 9, 10, 12 and 14 indicate packing rings made from the compound referred to above. These rings are cut as shown in sketch, *A*. Numbers 3, 6, 8

and 11 represent metal rings, made from pure tin. They are intended to keep the rubber rings in proper condition. These rings must be one-sixteenth larger than the piston rod and must remain in the form of one solid ring in order to stay centric and prevent scoring of the rod. The number 7 designates the "Linde" lantern with oil chamber. The lantern must be placed in the middle of the stuffing box so as to make proper oil connection. The oil is admitted at the point marked *a*, through a pipe connection from the oil trap and oil is forced into the stuffing box by the high-pressure gas

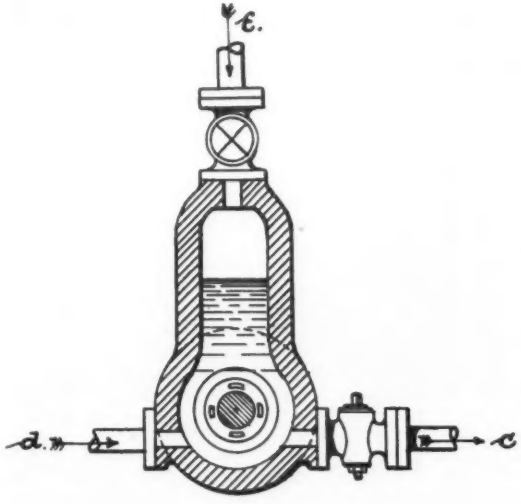


FIGURE 5.

in same, keeping the stuffing box and lantern always full and instantly replacing what little oil is carried into the cylinder by the rod. The number 13 is the stuffing box gland, which is supplied with oil through the inlet, *b*, from a small oil pump operated from the main shaft. This oil leaves the gland at *c*, and is conducted back to the oil basin to be recirculated. The number 15 is the oil gland which should be kept just tight enough to keep the oil in the stuffing box. As the "Linde" machine belongs to the class of the "wet" compression machines, there is always more

or less ice and moisture on the surface of the cylinder, and in view of the fact that the oil basin is placed directly under the stuffing box, care must be taken to prevent the dripping of water into the oil basin, as otherwise this moisture, in connection with other impurities, is liable to be forced into the system through the medium of the oil pump and it would then cause serious annoyance.

It is essential in the case of all stuffing boxes to maintain a uniform temperature; a change of temperature always affects either the tightness against gas leakage when too cold, or increases the friction when too warm. If the surrounding conditions of the machine will permit it, it is best to keep the piston rod at a hand-warm temperature, the packing material used in most stuffing boxes must expand slightly in order to serve its purpose fully; but frequently the practical running conditions are such that the gas returning from the system cools the cylinder and stuffing box either too much, or not sufficiently, which creates a condition as indicated above. A large oil receptacle in connection with the oil lantern of the stuffing box will be of considerable benefit to maintain moderate

temperatures in same and for that reason Fixary reconstructed the "Linde" stuffing box by surrounding the neck with a large oil chamber at the point of the lantern location within. Figure 5 illustrates the detail of construction fully. The oil pump supplies the receptacle with oil through pipe, *d*, connection, *c*, returns the unconsumed part of the oil to the pump, and at *e* a connection with the suction keeps the oil under pressure, A further means of preventing gas leakage and heating of the stuffing box is shown at Figure 6. The stuffing box flange is surrounded with a gas chamber,

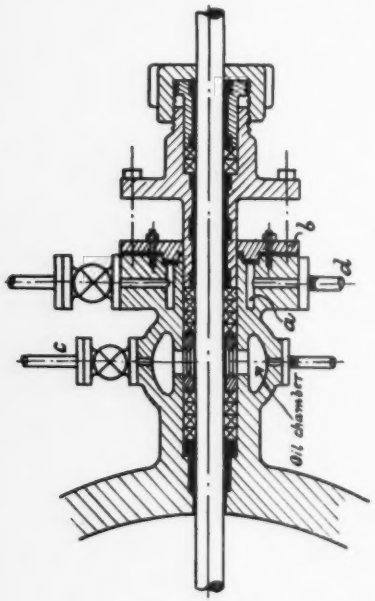


FIGURE 6.

a, which is closed up on the outer end by means of a flange, *b*. A liquid pipe with expansion valve is connected to the chamber at *c*, while connection, *d*, returns the gas to the suction side of the compressor. The expansion valve is kept slightly opened and allows the evaporation of a small quantity of liquid ammonia in gas chamber, *a*. The cooling effect so produced freezes the oil in the outer cotton packing rings and seals the stuffing box against gas leakage. Practical experience, however, has demonstrated that the freezing of the oil in the outer packing rings is superfluous and even harmful in many cases; therefore, it has been quite abandoned. Another disadvantage of the stuffing box is its extreme length so that practical advantages of this construction over the "Linde" stuffing box are not discernible.

Viaduct Erection on Section 10, New York Rapid Transit Railroad.

Section 10 of the New York Rapid Transit Railroad is a plate-girder viaduct about three miles long which extends from One Hundred and Forty-ninth street and Third avenue along Westchester avenue, Southern Boulevard and Boston Road to Bronx Park. The general features of the design and the method of erection were described in *The Engineering Record* of March 5. The present article describes some special features that have been developed in the progress of the work, and shows some of the traveler details which were not illustrated in the previous article. The character of the design is shown by the standard details which were illustrated in *The Engineering Record* of February 28, 1903. The most prominent features are the H-shaped columns made with a web plate and four bulb angles and their rigid connections to the transverse girders. The end sections of the web plates of the latter extend several feet below their lower flanges, and are field-riveted between the upper parts of the column angles, thus forming a portion of the column web and making it and the knee-brace and girder-web continuous.

The height of the viaduct varies to correspond with the track level from 15 to 60 feet above the surface of the ground. The lengths of both longitudinal and transverse girders vary, but are ordinarily about 50 and 30 feet respectively, corresponding to a depth of 5 feet. In the vicinity of the Southern Boulevard and Boston Road the alternate panels are 30 and 70 feet long, and at the intersection of Boston Road and West Farms Road, there is a special construction with long and deep upper and lower transverse girders which weigh about 23 tons each. These girders were erected by a pair of fixed gin-poles

braced together about 30 feet apart with two horizontal struts and intersecting diagonals so as to make a transverse trestle bent, the top of which was securely guyed in both directions. Each of the gin-poles was a 12 by 12-inch timber, 58 feet long with a six-part, three-quarter-inch steel-rope tackle lashed to the upper end. The bent was inclined longitudinally so that the upper end overhung the base about 5 feet. In this position it raised the vertical columns and afterward lifted the transverse girders to position and held them until the connections with the columns were securely bolted. After this the longitudinal girders were erected in the usual way by the booms of the traveler on the finished structure. When the panel was completed, the falsework was removed and the traveler advanced to erect the succeeding panels in the usual manner.

The regular 30-foot 10-ton transverse girders and the 50-foot 6-ton longitudinal girders were erected very rapidly, as described in the previous article. Each of these average spans weigh about 50 tons, and as many as seventeen of them have been erected in one eight-hour day by a force of eighteen bridgemen and four other men. This rapid progress was due partly to the excellent organization of the men, each of whom was trained to perform the necessary successive duties in the quickest and most efficient manner. It was also facilitated by the simplicity and efficiency of the traveler, which consisted of a 40 by 36-foot horizontal platform carrying two stiff-leg boom derricks in front, which erected the main girders and columns, and a small stiff-leg boom derrick, called a jinniwink, in the rear, to handle the lateral bracing and other light material which was hoisted after the principal connections in a panel had been made.

The traveler had four single-flange cast-iron wheels with very long treads which rolled on the top flanges of the outer longitudinal girders and had play enough to enable them to slip back and forth and move around curves without difficulty. Adjacent to each wheel was a clamp operated by a vertical screw and hand-wheel to anchor the traveler securely to the top flange of the girder. The derrick fittings, as shown in the accompanying details, were most of them of the Terry patents. At the foot of the mast there was a ball-and-socket bearing which was locked so as to prevent any danger of the mast kicking out of position. At the top of the mast the connections were all made to a riveted steel box bolted to the timber so as to avoid any cutting or framing of the latter. This box contained the necessary sheaves and pin connections for links, and also received the gudgeon pin, to which was attached a heavy forged goose-neck for the single stiff-leg and a horizontal channel which received the transverse strut, batter-post and pin-connected diagonal rod. The derrick was swung horizontally by a bull wheel framed to the bottom of the mast so as to clear the foot-block and the boom, the latter revolving between the wheel braces which formed a pocket for it. The lower ends of the stiff-legs were pin-connected through jaw-plates to riveted shoes. The latter were made with vertical web plates riveted to the flanges of horizontal channels, which were securely bolted to the sills of the traveler platform.

There were in all ten four-men rivet gangs which drove an average of 200 field rivets daily. Most of the rivets were driven by Boyer pneumatic hammers supplied with compressed air by an Ingersoll-Sergeant compressor located with a 60-horse-power horizontal boiler, in a house built under the structure and moved about once a mile. The compressor was connected to a pair of vertical 15-inch receiving cylinders about 6 feet high, beyond which a 4-inch horizontal delivery pipe terminated in a T with vertical branches, to the upper one of which the distributing main was connected. The lower branch was connected to a vertical pipe about 2 feet long and 3 inches in diameter, valved at the bottom. This formed a trap in which the oil was collected and whence it was drawn off, thus saving much difficulty and annoyance in the operation of the hammers.

The pneumatic hammers were used in combination with a special yoke which provided for holding the set against the rivet while the latter was being driven and secured better and more rapid work with less labor. This arrangement is shown in the accompanying details and is covered by a patent issued to Mr. E. F. Terry. The yoke weighed about 25

pounds, and was made of cast steel with a clearance of 8 inches vertically and horizontally. It received the Boyer pneumatic hammer which was securely clamped to it and could be released almost instantly by turning a thumb screw and opening the gate which locked it to the yoke frame.

On each side of the hammer there was attached to the upper part of the yoke a vertical cylinder containing a plunger designed to engage the member adjacent to the rivet head, while the opposite side of the member was engaged by the lower arm of the yoke. When the hammer cup was placed on the point of the rivet, the rivet set carried by the lower arm of the yoke engaged the original head of the rivet. The three-way valve was opened and the air was admitted to the yoke cylinder and to the clamp cylinders. As the piston in the yoke cylinder was fixed to the pneumatic hammer, the cylinder itself was moved upward relatively to the hammer, and, carrying the yoke with it, caused the rivet set to force the rivet tightly against the member in which it was placed. Simultaneously the plungers in the clamp cylinders were forced downward and reacted against the yoke so as to clamp the different pieces in the member together and hold the hammer securely while it was in operation. As soon as the rivet was driven the hammer was stopped by operating the trigger, and the three-way valve being open, the pressure was released in the yoke and clamp cylinders. The set and cup were then disengaged from the old and new heads of the rivet respectively and the machine was easily removed. This attachment for the hammer proved very convenient and did not require much repair or adjustment. With it more and better rivets of the same character could be driven in a given time than by the same men and hammer when the rivets were held up by a hand-dolly against the riveter.

The riveters were followed closely by the track men, who framed and laid the track. Their operations were much facilitated by the use of a special traveling sawmill which advanced on the finished track, keeping close to the rail head. There was a low rectangular timber tower with transverse and longitudinal bracing which supported on the upper deck a stiff-leg derrick used to lift the timber from the street to the viaduct. On the lower sills of the tower there was a platform, and the interior of the tower was fitted up as a sawmill and boring mill with the machinery belted to a longitudinal jack shaft on each side, which was driven by a 20-horse-power Metropolitan horizontal engine operated by steam from the boiler of the adjacent hoisting engine.

The tower was mounted on standard double-flange traveler wheels spaced to travel on the inside rail of each outside track. Three longitudinal roller tables extended through the tower from end to end about 2 feet above the floor, one on the centre line and one on each side. The side tables were continued about 23 feet beyond the front and rear ends of the tower, where they were supported on wooden cantilever stringers with guyed extremities so as to be carried clear of the top of the viaduct. On one side of the tower the 6 by 6 and 6 by 8-inch guard rails were delivered from the rear to the roller table and advanced on it to the first saw table, where two circular saws were set so as to simultaneously cut the ends square and cut the timber half way through, 18 inches from the end, in order to make the lap splice. After one end had thus been sawed, the stick was rolled 180 degrees and moved forward to a second table where the other end was similarly cut without the necessity of turning the stick end for end. The stick was then moved across on transverse skids to the centre roller table, at each end of which there was a band saw which made a longitudinal cut 20 inches long from the end of the timber and completed the lap for the splice. The timber was then delivered over the front extension of the roller table and placed in position on the track. The timbers averaged about 26 feet long, but were not uniform, and they were cut as long as possible and splices made wherever needed.

On the opposite side of the tower several vertical augers were provided to bore the ties and guard timbers. It was found, however, that the unavoidable slight variations in the distances and dimensions made it difficult to bore these members satisfactorily before they were put in place, and these machines were abandoned, all holes being bored by pneumatic boring machines after the

timbers were assembled together. One of these hand machines bored two three-quarter-inch holes 16 inches long in one minute. They were preceded by a pneumatic machine fitted with an expansion bit and stop which countersunk for the washers, and was operated at the rate of four holes per minute. If the holes could be drilled in advance by template it was considered that the work could be done somewhat more economically by the fixed machines in the sawmill, but practical considerations made it more satisfactory to bore them by hand as here described. Each guard rail is bolted to alternate ties, and all ties are secured to the girders with two hook bolts so that it was necessary to drill the equivalent of one hole through each end of every tie. With this apparatus 200 lineal feet of triple track was laid and the ties and guard rails framed and bolted by a crew of 60 men in each eight-hour day. The framing was done more rapidly than the track-laying, and when the band saws were not employed, as above described, they were used to cut the waste and small blocks into wedges for use on this work and elsewhere.

The Terry & Tench Co. were the subcontractors for the erection, which was done in accordance with the requirements of the New York Rapid Transit Railroad Commissioners, Mr. William Barclay Parsons, chief engineer, and Mr. George S. Rice, deputy chief engineer.—*The Engineering Record.*

Notes.

The Binghamton (Tenn.) car works have been reopened by the American Car and Foundry Company. Compressed air is now largely used to operate hoists and pneumatic tools.

Among the new English corporations registered is the Shaw Rock Drill and Machinery Co., Ltd., with a capital of £12,000. The company plans to handle the Shaw drills in England and other countries.

Mr. H. B. Griner, formerly assistant western manager of the Philadelphia Pneumatic Tool Company at Chicago, Ill., has been appointed sales manager of that company with headquarters in the main office at Philadelphia.

Mr. Julius Keller, president of the Philadelphia Pneumatic Tool Company, has just completed a trip through the western portions of New York and Pennsylvania, and the most important points in Canada. He was successful in obtaining quite a number of nice orders for the Keller tools.

The *Iron Age* of October 13th contains an interesting description of the new foundry of the Hilles & Jones Company at Wilmington, Del. Air under pressure for pneumatic tools, hoists and other purposes is piped to all parts of the plant. The present compressor is of the Ingersoll-Sergeant make.

A useful application of compressed air has been suggested by Librarian Montgomery, of the Pennsylvania State Library, at Harrisburg, Pa. He believes it can be utilized to advantage for dusting the books in the library, doing the work much more effectively and with a great saving of time.

The Delaware & Hudson Company has installed a compressed air plant in its railroad yard at Scranton, Pa. This plant will be used for testing air brakes. Under the old arrangement a locomotive was used and only one car could be tested at a time. It will now be possible to test a train of 75 cars.

The Globe Pneumatic Tool Company has been organized at Lyons, N. Y., with a capital stock of $100,000. Pneumatic tools will be manufactured and sold. The directors are Philip S. Hill, Frank M. Van Wagoner and Frank A. Clary, of New York; M. J. Duffy, of Jersey City, N. J., and H. T. Mead, of East Orange, N. J.

The Gunnell Tool Company, Manitowoc, Wis., has been organized to manufacture pneumatic tool specialties, such as pneumatic rivet heating forges, pneumatic hose couplings, riveting machines, etc. The company is making a specialty of forge and hose couplings. The incorporators of the company, which is capitalized for $5,000, are Elias Gunnell, Lynford E. Geer and Charles C. West.

The Imperial Works of the Oil Well Supply Co., at Oil City, Pa., are de-

scribed in a a recent issue of the *Engineering Record*. The air compressor is located at the power house. It is of the Class "J C" type, built by the Ingersoll-Sergeant Drill Co. and is driven by a 75 H. P. De Laval steam turbine. The air is compressed in two stages to 80 pounds pressure. The capacity of the compressor is 519 cubic feet of free air per minute.

Although only 200 yards of tunneling are lacking to complete the Simplon tunnel, the engineers in charge are reported to be seriously troubled about its completion. A spring of boiling water made its appearance in the heading and necessitated the temporary cessation of work. New machine is being installed to pump cool air into the tunnel and reduce the temperature. It is feared that in the middle of the mountain, which has nearly been reached, there exists a molten mass which may prove an insurmountable obstacle.

A valve mechanism for air compressors has recently been patented in England by A. W. & Z. W. Daw, of London. It provides for the combination of a compression cylinder, a delivery valve opening outward therefrom and having its rear face exposed to the pressure in the receiver, a cylinder open at its end to the pressure in the receiver, a spindle provided with a piston on its inner end adapted to work in said cylinder, means connecting said piston with said valve, a spring for closing said valve, a second piston mounted on said spindle, a cylinder in which said last-mentioned piston works, a valve governing the supply and exhaust of the cylinder for the second piston, a pipe leading from the receiver to the valve chest of said governing valve, and means controlled by said governing valve for buffering the stroke of the second piston.

The use of suction apparatus for household cleaning is now so general that it no longer arouses comment. A form of apparatus in which the same principle is involved has recently been brought out in Paris, and will doubtless prove of interest, although the principle is not new. The contrivance in question is a portable pneumatic duster, consisting of a bellows constructed somewhat after the fashion of an accordion. From the bellows a tube leads, by which an ordinary duster is carried. Within the bellows packing material is contained, which retains the dust gathered. The duster is passed over the object to be cleaned in the ordinary way, and the dust which is displaced is drawn into the tube by operating the bellows. As soon as the dust is caught by the packing material it cannot be discharged by compressing the bellows. When the packing is quite full of dust it is taken out and thrown away and new packing is inserted.—*Scientific American.*

For mines and other places which get flooded the air lift pump seems to be a useful invention. The peculiarity of this pump is that it does its work without having any machinery placed below the surface of the earth. It can also be worked at any reasonable distance from the central source of power. Explained simply, compressed air is pumped down on the water, which rises up a second length of piping. So long as the air pipe is tightly jointed the machinery can be any distance away from the bore-hole. Another advantage obtained by using this pump lies in the fact that the yield of a deep well pump is the measure of the capacity of the bore-hole. Now a 6,000 gallon pump requires a hole ten inches in diameter, while the same yield can be got out of a six-inch hole by the air-lift system. It is hoped to apply this system for supplying the water for the large areas of watercress beds which are in the neighborhood of London, and which are supplied by artesian wells.—*Birmingham (Eng.) Post.*

Picking cotton is a slow and tedious operation and doubtless the largest item of expense in growing this staple product. As a means for performing this work, Mr. Rudolph Getzlaff, of Amsterdam, Ga., has invented a pneumatic machine, which he claims to be thoroughly feasible and efficient in operation. This machine relates to cotton-picking devices in which a current of air is set up in a tube by means of a suitably arranged fan or blower, the same discharging into a receptacle, the suction thus produced serving to remove from the plants the open bolls of cotton which are ready for picking, and to convey them through a tubular conduit and then through the

blower mechanism into the receptacle. This apparatus is mounted on wheels and is designed to be driven down the rows of cotton plants in the field. As the end of the suction tube passes over the open bolls the cotton is separated from the plant. The machine is simple in construction and the general arrangement is a decided novelty.—*American Inventor.*

Mine signaling by compressed air has proved to be superior to other methods of signaling in the Le Roi shaft, according to a paper read before the Canadian Mining Institute by Messrs. Macdonald and Thompson. The system employed is merely the installation of the well-known Westinghouse compressed air train signal, in which the pulling of a cord operates a compressed air whistle. The system at the Le Roi mine has been in operation more than a year and a half without any repairs whatever. Regular Westinghouse apparatus as used on passenger trains was furnished by the Westinghouse Air Brake Co., and the entire cost of an installation to a depth of 1,000 feet, with signaling stations 100 feet apart, was $125, including labor of installation. The apparatus has two distinct advantages over the ordinary bell-pull system: (1) Few moving parts, hence reduced liability of derangement; and (2) the signal sender has always a means of knowing whether his signal has reached its destination.—*Engineering News.*

Several long-distance pneumatic tube lines have been projected but none, so far, have been carried to a successful conclusion. The latest service of this kind to be planned is a system to connect Chicago and Milwaukee, a distance of 85 miles. The Universal Pneumatic Transmission Company makes the proposal and bases its ability to carry out the plan on its several successful installations of pneumatic tube systems in a number of the department stores in Chicago. It is proposed to establish a tube eight inches in diameter and capable of carrying packages as heavy as 500 pounds. The cost of building the line is reported to be placed at $5,000,000, at the rate of $62,500 a mile. The expense of maintenance and operation will be, it is asserted, much less than for the present systems of carrying freight.

Instead of forcing air under high pressure behind the carrier, the Dinspel-Stoetzel vacuum system will be used. It is planned to divide the line into sections of two and one-half miles each and use a system of air locks which will permit the carrier to make a continuous passage.

So far efforts have been confined to securing the promise of enough business to make the tube service pay.

"The strength of Gibraltar" has become a by-word of nations, yet those using it little realize all it means. The strength of that fortification is well illustrated by the manner in which coal is stored. This is done by a very curious plant, which has just been completed for the pumping station at Landport.

The coal store, boiler house and the engine room adjoining are worked under compressed air, and are necessarily air-tight. The store to which the coal has to be conveyed is hewn out of the solid rock, and is absolutely bomb-proof. A special feature is the arrangement of the coal plant in such a way that it does not interfere with the air pressure. The coal is lifted from the coal tip 57 feet below the horizontal traveler. The skip by which the coal is conveyed is raised by means of a steel wire rope, working over pulleys and round a driving drum. The skip is lowered into a receiving hopper, where it discharges. At the bottom of the hopper is an automatic arrangement, consisting of a hinged door controlled by a lever and a balance weight; this door opens when there is sufficient coal in the hopper to overcome the balance, closing again as soon as the coal is discharged, and thus avoiding the escape of air. From this point the coal gravitates into the coal store, where it is used in the boiler house for generating steam for pumping purposes. The time occupied by the skip in traveling from coal tip to coal store is two minutes. At this end, and on a level with the motors, a sentry box is hewn out of the rock, where the man who controls the gearing for hoisting the skip is housed, and has practically a full view of all three operations.—*Popular Mechanics.*

The Government employees at Chatham complain that pneumatic tools are detrimental to the health of the workers, some of whom become physical wrecks,

the muscles of the arm becoming seriously affected, while the hearing is destroyed by the great noise. It is admitted that there is considerable truth in these contentions, but it is affirmed that there is an ulterior motive in bringing the subject up at the present time. On this point the *Engineer* remarks:

"The question of piecework prices for pneumatic work is at present under consideration, and we are possibly correct in believing that this discussion is to be regarded as a diplomatic move on the part of the men, who obviously are likely to receive higher wages if they can prove such work to be particularly onerous. No one who has any experience of the use of pneumatic tools can deny that it has objectionable features; the vibration and the noise when chipping or caulking tools are used on hollow structures are very considerable. The former is being reduced by improvement in the design of the tools, and its effect on the men may be greatly modified by training the muscles gradually to withstand the peculiar action. If a man is put suddenly onto the use of the pneumatic hammer for many hours at a time he will suffer severely, but if he accustoms himself to its use by slow degrees he will feel no ill effect. The question of the noise is less easy of solution, and good may possibly result from attention being directed to it. In conclusion, it may be remarked that, while pneumatic tools have been in use all over the country for many years, no serious action has ever been taken against them by the men."—*Iron Age.*

By a canvass of the special tools operated by compressed air in most railroad and manufacturing shops, one of the first facts to impress the observer is the apparent waste of energy going on in the compressing and transmission, and to the point where it is taken off to give up its low percentage of useful work. In fact, there is no other power generated and used so extravagantly as compressed air in the ordinary application of it in the average shop, as will be seen in the means taken to compress it and in the devices used to utilize it. Such a condition would not be tolerated in the use of steam, and yet the economy in expansion of air is a sealed book in some of the best labor-saving tools operated by that medium. And so with the air pumps, which are, from necessity, the only means by which air pressure is possible in too many instances. The waste incurred by their use should be curtailed by the installation of a suitable compressor of a size liberal enough to satisfy any prospective increase of air driven tools, for such increase is always rapid enough when the air supply is assured.

The only thing that can weaken the above proposition is the expense involved, since, with an efficient compressing plant, there are other refinements, like reheating, which work out economies, all of them tending to hold the non-expansion pump in service, when once alarm is taken over the cost of a suitable plant. It will be found that air can be used expansively at the tool without reheating and be made to give a fairly reasonable degree of economy, by contracting the exhaust port sufficiently to prevent congelation, which scheme has been worked out satisfactorily on air motors used in coal mines. The resulting back pressure due to such contraction of the port is, of course, the price paid for prevention of freezing at the exhaust, but the loss of efficiency is too slight to be considered, when compared with the loss due to the full stroke use of air at the output end. Some attention paid to the expansive use of air without reheating will be productive of results even when the compressors are not above criticism.—*Railway and Engineering Review.*

Experiments about to be made here with a small stope drill adds importance to a pneumatic hand-drill that is attracting the attention of mine managers. It is claimed that this machine, which might lead to very great economies, including hammer and drill, weighs but 16¼ pounds and requires to operate it but 17 cubic feet of free air per minute at a pressure of 80 to 100 pounds. The machine is portable, and was designed with that idea in view. It can be handled by one man and can be operated without tripod or column. The machine, including column arm and clamp, weighs but 83 pounds, and it is supplied with an automatic feeder which is released by a ¼-inch valve. By opening this valve which is attached to an air hose, the air forces the drill against the rock. The hammer is operated by another ¼-inch valve. When this valve is opened it allows the air to enter the machine, which

starts the hammer in operation. Then as the hammer forces the drill bit into the rock, the exhaust air from the drill goes through a hole running lengthwise of the drill bit and forces the dirt and dust from the drill hole. The dust is overcome by a water attachment, which consists of a tank 10 inches in diameter and 30 inches high, filled with water. Air is forced into the top of the tank, which gives it pressure. By releasing a ¼-inch valve attached to a water hose (which is also attached to the drill), the water is thrown against the rock and dampens the dust. This attachment can be used or not, as desired by the operator. The machine consists of but four pieces, viz., handle, piston, barrel and nut. No valves or springs are used in the mechanism of the drill. The drill bit, which is known as the "wagon wheel" bit, has fourteen cutting edges. Capacity of the drill depends entirely upon the character of the rock. It is asserted by the manufacturers that this drill, operated by one man, will do as much work in eight hours as ten miners, or cutting from 100 to 150 feet per day.—*South Africa.*

Work on the construction of the twin-tube tunnel of the New York Rapid Transit Railway, from Battery Park, New York, to Joralemon street, Brooklyn, is being pushed with a total force of about 500 men in the three eight-hour shifts which maintain the work constantly day and night. At the New York end both tubes are being built in rock excavation, which has been carried under the river, and is now about 1,300 feet beyond the foot of the shaft. The work is being done under an air pressure of about 12 pounds, which is provided more to assist in keeping the tunnel dry and in order to be prepared for any sudden necessity than because it is actually required at present. At the Brooklyn end the north tube has been built nearly to the bulkhead-line. As soon as it has been carried far enough beyond this point a steel shaft will be sunk to it with a pneumatic caisson, and will afford access to the tunnel, so that the present shaft on Joralemon street can be abandoned, thus removing the obstruction which it now presents to traffic.

Two bulkhead walls about 300 feet apart have been built across the tunnel near the foot of the shaft and are made of brick work 2 feet thick, heavily braced by inclined timber struts on the shore side. Through each of these bulkheads there are two horizontal cylindrical air locks; the lower one is is 6½ feet in diameter and 20 feet long, and is available for cars and materials as well as for men. The upper one is 3 feet in diameter, 32 feet long, and is intended for an emergency lock and for the passage of rails and long materials without too great a loss of air. Between the two locks a pressure of about four pounds is maintained, and beyond them a pressure of about 10 pounds is now required. These locks will be moved from time to time as the heading advances and it is found that the 3-foot braced bulkhead wall is as strong as the 4-foot solid brick wall formerly used, and can be much more easily cut out.

Excavation is made under the special hydraulic shield already described, which has proved very satisfactory, and the spoil is delivered to the shaft in cars hauled by steel cables from the drums of Lidgerwood hoisting engines seated on platforms in the upper part of the tunnel and driven by compressed air. The Brooklyn power house is being extended by the addition of a 500-horse-power battery of Heine boilers. The best average monthly progress per heading has been 200 feet. The work will apparently be completed ahead of contract time.—*Engineering Record.*

The essential features of a pneumatic tube line are four: a suitable conduit, or tube; a carrier for passing through the tube; a transmitter, or device for dispatching the carrier, and a receiver, or apparatus for arresting the carrier and delivering it from the line. The problem of a suitable conduit is not nearly so simple as it may seem. At the time when the construction of the first large tube line in Philadelphia was undertaken, no pipe or tube of a suitable nature could be purchased in the market. Experiments were made with pipes of various sorts until the invention of a special machine for boring cast-iron pipes finally gave the advantage to this material, and it has been adopted in all subsequent constructions. The pipes are bored smooth as a gun-barrel on the interior, and the ends are turned and counterbored so as to ensure alignment, and at the same time to permit sufficient angle between consecutive lengths to admit of a considerable deflection when it is desired to

avoid obstructions. The carrier adopted for the present system travels upon a pair of bearing-rings near each end of it. These are of specially prepared composition, and will cover ten thousand miles before they are worn out. The transmitters are of several different types. The first requirement is that they shall introduce the carrier into the air current without interrupting the flow, and that the operation shall be as simple as possible. The latest form of transmitter accomplishes this without other act on the part of the operator than that of dropping the carrier into the opening in the floor. The receivers are of four types, each adapted for some special situation or condition of operation. The simplest as well as the newest is without moving mechanism of any kind, and this is the type exhibited by Mr. Batcheller, at Ranelagh Lodge, Fulham. In each of the other three types the carrier is brought to rest by the air-cushion formed ahead of it in entering the closed section of tube. When placed where the pressure of the line is atmospheric, the carrier is automatically discharged by the opening of the gate that normally closes this section; where the pressure of the line is above that of the atmosphere a special form of receiver is provided, which delivers the carrier without escape of air. When it is desired to connect several stations on a single line and to be able to dispatch from one end of the line to any of these stations, an automatic machine, called the "intermediate receiver," is provided. By means of metallic discs of graduated diameter borne on the front end of the carrier, this machine selects the carriers intended for delivery and passes all carriers for stations beyond.—*Illustrated London News.*

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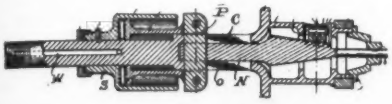
U.S. PATENTS GRANTED SEPT., 1904.

Specially prepared for COMPRESSED AIR.

769,158. FLUE-CUTTER. Charles Gabriel, Chicago, Ill. Filed Oct. 8, 1903. Serial No. 176,207.

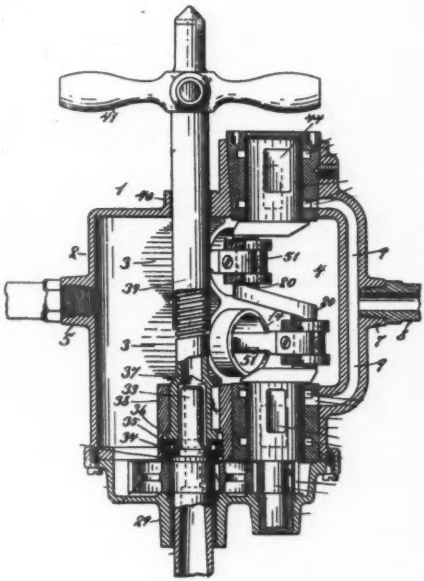


A flue-cutter comprising a cylindrical head, a hollow shank at one end of same, an annular flange on said end of said head, an annular shoulder of less diameter than said head at its forward end, a removable collar of greater diameter than said head, mounted on said shoulder, a nut adapted to enter said head at its forward end and having an annular flange engaging said collar to hold same in place, a central opening in said nut, a hollow shank at the rear end of said cutter-head, having longitudinal slots, a plurality of radial guides in said head, cutter-heads mounted in said radial guides, said cutter-heads being provided with inclined T-shaped guide-slots in their inner ends, a shaft movable longitudinally in said head and said shank and having a tapered enlargement between its ends, T-shaped longitudinal guides on said tapered enlargement adapted to enter said guide-slots in said cutter-heads, a cross-head on said shaft projecting through said slots in said shank and devices on said shank engaging said cross-head for moving same longitudinally relatively to said cylindrical head and cutters, for imparting radial movement to the latter, comprising a cylinder, closed at one end, rigidly mounted concentrically on said shank, a piston longitudinally movably mounted on said shank within said cylinder, rigid connection between said piston and said cross-head and means for supplying fluid, under pressure, to said cylinder to impart relative motion to said piston substantially as and for the purpose described.

769,233. CASH-BOX FOR PNEUMATIC CASH-CARRIER SYSTEMS. Charles A. Pfluger, Chicago, Ill., assignor of one-half to John B. Weir, Chicago, Ill. Filed Aug. 10, 1903. Serial No. 168,878.

769,234. AUTOMATIC CAR-BRAKE. Claude F. Pierce, St. Louis, Mo. Filed May 16, 1903. Serial No. 157,480.

769,247. FLUID-PRESSURE ENGINE. Sidney W. Brainard, Cleveland, Ohio, assignor to The Cleveland Pneumatic Tool Company, Cleveland, Ohio, a Corporation of Ohio. Filed Jan. 2, 1904. Serial No. 187,441.



In a portable fluid-pressure engine, the combination of a plurality of cylinders arranged in the same transverse plane and each cylinder of a set in the same radial plane as a cylinder of the adjoining set, pistons and pitmen in the cylinders, a crank-shaft having the pitmen of each set pivoted to one crank and having journals formed into valves, one valve for each set, and journal-bearings having ports and passages for the motive fluid and controlled by the journal-valves.

769,276. PORTABLE FORGE. John Reilley, Jersey City, N. J. Filed Dec. 19, 1903. Serial No. 185,826.

A forge, the combination with a casing, a removable receiver, a bowl having an outlet into the receiver, an air-receptacle, and a valved connection between the receptacle and bowl; of a cylinder, trunnions thereon journaled in the casing, valved inlets and outlets to the cylinder, a piston within the cylinder, a crank-shaft, a rigid connection between the crank-shaft and piston, and tubular connections between the outlets and the receptacle.

769,332. VALVE-GEAR FOR FLUID-PRESSURE ENGINES. Edwin E. Arnold, Wilkinsburg, Pa., assignor to The Westinghouse Machine Company, a Corporation of Pennsylvania. Filed Feb. 6, 1903. Serial No. 142,236.

769,358. CAR-BRAKE. August G. Sandman, St. Denis, Md. Filed Mar. 9, 1896. Serial No. 582,355.

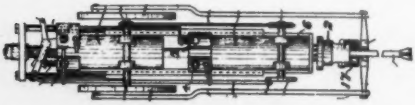
769,359. COMBINED AIR AND HAND BRAKE. August G. Sandman, St. Denis, Md. Filed Apr. 1, 1896. Renewed Feb. 13, 1904. Serial No. 193,469.

769,373. VALVE-OPERATING MECHANISM. Edwin E. Arnold, Wilkinsburg, Pa., assignor to The Westinghouse Machine Company, a Corporation of Pennsylvania. Filed Feb. 6, 1903. Serial No. 142,237.

A fluid-pressure engine, the combination with a valve having a stem provided with a piston, of a cylinder for said piston, a second piston located in said cylinder and movable upon said stem to lift the valve, an eccentric and connections between the same and the second piston for positively operating and controlling the latter throughout its range of movement.

769,424. VALVE FOR PNEUMATIC-ACTIONS FOR MUSICAL INSTRUMENTS. Morris S. Wright, Worcester, Mass. Filed July 8, 1902. Serial No. 114,727.

769,465. ROCK-DRILL. William Brady, San Francisco, Cal. Filed Dec. 17, 1903. Serial No. 185,486.

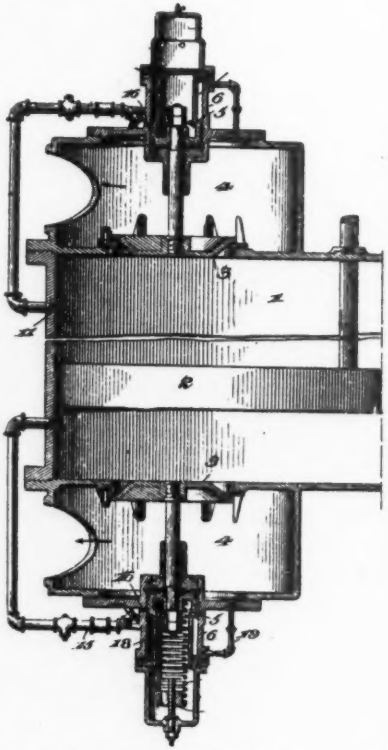


The combination in an apparatus for striking blows, of cylinders fixed axially in line, pistons movable in the cylinders having a piston-rod common to both and extending through the end of one of the cylinders, a tool-carrying head fixed to the piston-rod, a device for returning the parts after each stroke, said device having one end adapted to reciprocate in line with the tool-head, a journal-shaft having cranks with which the rear end of said device is connected, a fly-wheel carried by said shaft, and receiving motion from the impulses of the engine, the momentum of said fly-wheel acting through the crank-shaft connections to retract the drill and pistons after the latter has been impelled forward.

769,482. PRESSURE-REGULATOR. Arthur Kleinfeldt, Hoboken, N. J., assignor to Sophie Kleinfeldt, Hoboken, N. J. Filed Mar. 18, 1904. Serial No. 198,756.

A combined pressure regulator and indicator, the combination with a gas-chamber and a diaphragm subject to the pressure of gas therein, of indicating mechanism bearing freely against one side of the diaphragm, and valve mechanism to control the admission of gas to said chamber bearing freely against the other side of the diaphragm, whereby the pressure of gas in said chamber actuates both the indicating mechanism and the valve mechanism.

769,833. AUTOMATIC AIR-DISCHARGE VALVE FOR BLOWING-ENGINES. Alexander K. Rarig, Columbus, Ohio. Filed Mar. 2, 1903. Serial No. 145,732.



A blowing-engine, the combination of an air-discharge valve, a piston working in a cylinder and controlling said valve, a pipe supplying pressure to said cylinder at a point beneath the

same, means opposing the exhausting of said pressure at such point, and a branch pipe communicating between the pressure-pipe and the cylinder at a point above the lower limit of the piston, through which pressure is exhausted from the cylinder; said valve being biased to closed position.

769,565. COMPRESSED-AIR SUPPLY FOR ELECTRIC VEHICLES. Roland Le Baron Owen and Robert O. Le Baron, Pontiac, Mich. Filed Sept. 30, 1903. Serial No. 175,175.

A compressed-air supply for electric cars, having a compressed-air tank, an air-pump, a gearing for actuating the pump from a movable part of the car, and a fluid-controlled mechanism, controlled by the operating-lever of the electric car and connected with the gearing, to throw the latter in or out of gear by fluid-pressure from the said tank, as set forth.

A compressed-air supply for electric cars, comprising a compressed-air tank, an air-pump for supplying the tank with compressed air, driving means for operating the pump from a movable part of the car, a fluid-controlled mechanism having connection with the said tank, for throwing the driving means in and out of gear, a valve in the said connection, controlled by the operating-lever of the vehicle, and an automatic controller connected with the said valve, the said automatic controller comprising a casing and two spring-pressed pistons movable therein, one of the pistons being connected with the valve and the casing being connected with the said tank, as set forth.

769,838. AUTOMATIC AIR-BRAKE MECHANISM FOR CARS. William H. Sauvage, New York, N. Y., assignor of fifty-one two-hundredths to George F. Kissam, New York, N. Y. Filed Oct. 25, 1902. Renewed Jan. 19, 1904. Serial No. 189,756.

769,889. PNEUMATIC MUSIC-PLAYING INSTRUMENT. Charles L. Davis, Meriden, Conn., assignor to Wilcox & White Company, Meriden, Conn., a Corporation of Connecticut. Filed Mar. 29, 1904. Serial No. 200,540.

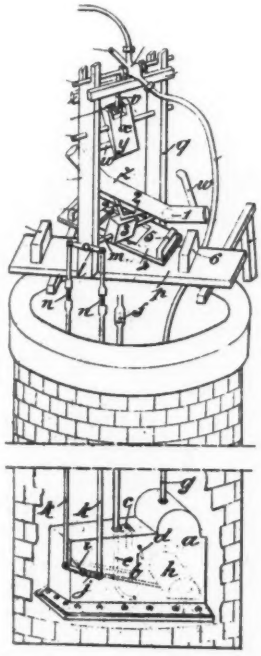
770,080. DEVICE FOR PROTECTING PNEUMATIC TIRES. Emile Lapisse, Elbeuf, France. Filed Dec. 23, 1903. Serial No. 186,316.

770,128. PNEUMATIC VEHICLE-SPRING. Benjamin F. Teal, Philadelphia, Pa. Filed May 28, 1904. Serial No. 210,260.

770,153. PNEUMATIC PUMPING OR CONVEYING DEVICE. Willard J. Bell, Newaygo, Mich. Filed June 7, 1901. Serial No. 63,617.

The combination with the pump-chamber provided with an inlet-pipe and an outlet-pipe, each provided with a check-valve, of an air-receiver, a pipe leading from the receiver to the pump-chamber, a valve in said pipe for controlling the passage of air from the receiver to the pump-chamber, a valve controlling an exhaust-port in said pipe between said first-named valve and the air-receiver, a rocker-arm pivoted at one end and connected to said valves so as to simultaneously open one and close the other, a cam arranged to oscillate said rocker-arm to actuate the valves, and means actuated by the compressor-driving mechanism for operating the cam, substantially as described.

770,279. COMPRESSED-AIR-OPERATED WATER RAISING OR FORCING APPARATUS. Elie Gaucher, Constantinople, Turkey. Filed Mar. 15, 1904. Serial No. 198,238.



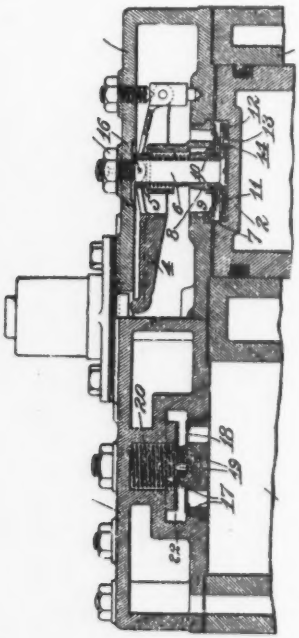
A compressed-air-operated water raising or forcing apparatus comprising a closed receptacle

having a compressed-air inlet, a water-inlet and a water-outlet, a float therein operating a spindle projecting outside the wall of said receptacle, a lever device connected thereto and operating a spindle carrying a balance-striking device, a lever operated thereby and a valve operated by said lever to alternately connect the float-receptacle with the compressed-air supply and the atmosphere, substantially as described.

770,160. AUTOMATIC AIR-BRAKE COUPLING. Fred M. Caron, Worcester, Mass., assignor to M. Percival Whittall and Charles H. Flint, Worcester, Mass. Filed Mar. 19, 1904. Serial No. 198,947.

770,531. PNEUMATIC-TIRED VEHICLE. Camille Mercader, Pittsburg, Pa. Filed Nov. 13, 1903. Serial No. 181,069.

770,783. VALVE FOR AIR-COMPRESSORS. Edwin H. Steedman, St. Louis, Mo. Filed Nov. 2, 1903. Serial No. 179,597.

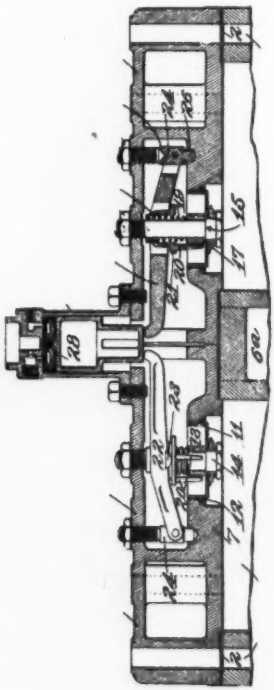


A valve for air-compressors, the combination with a cylinder-head, of a valve-seat introduced from the cylinder side of said head, and a bolt for securing the same in position, said bolt extending to the exterior and having an opening in its outer end for the introduction of a lubricant; substantially as described.

770,611. DETACHABLE PNEUMATIC TIRE. Charles S. Scott, Cadiz, Ohio. Filed June 15, 1904. Serial No. 212,699.

770,645. PNEUMATIC EYE EXERCISER AND TESTER. Gustav E. Lundgren, Elgin, Ill. Filed May 21, 1904. Serial No. 209,107.

770,785. PRESSURE CONTROL FOR AIR-COMPRESSORS. Edwin H. Steedman, St. Louis, Mo. Filed Nov. 2, 1903. Serial No. 179,599.



An apparatus of the character described, the combination with the cylinders of a duplex single-acting air-compressor, of separate hollow cylinder-heads arranged thereon, a suction-chamber in each of said heads, said suction-chambers communicating with each other between the two heads, a suction-chamber in the walls of the cylinders also in communication with the said

suction-chambers in the heads, a suction-valve in each suction-chamber, which valve is introduced from the cylinder side into the inner wall of the cylinder-head, and a common means for stopping the operation of said suction-valves; substantially as described.

770,790. PNEUMATIC TRACKER-BAR. Philip Wuest, Jr., Philadelphia, Pa. Filed Jan. 19, 1904. Serial No. 189,731.

770,795. PNEUMATIC-TIRE COVER. Charles B. Buxton, Palmerston North, New Zealand. Filed July 13, 1903. Serial No. 165,299.

770,938. PNEUMATIC-DESPATCH SYSTEM. Franklin S. Smith, Philadelphia, Pa. Filed Jan. 5, 1904. Serial No. 187,823.

771,118. HOOD FOR PNEUMATIC STACKERS. Frank Bechtel and Edward M. Hagar, Anchor, Ill. Filed Apr. 18, 1904. Serial No. 203,695.

771,156. VALVE FOR PNEUMATIC TIRES. John E. Keller, Jr., Litchfield, Conn. Filed Dec. 29, 1903. Serial No. 186,986.

771,190. PNEUMATIC-TIRE GUARD. Laurent Vanderperre-Simon, Brussels, Belgium. Filed July 17, 1903. Serial No. 165,988.

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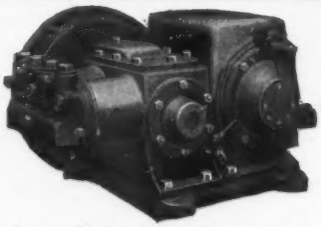

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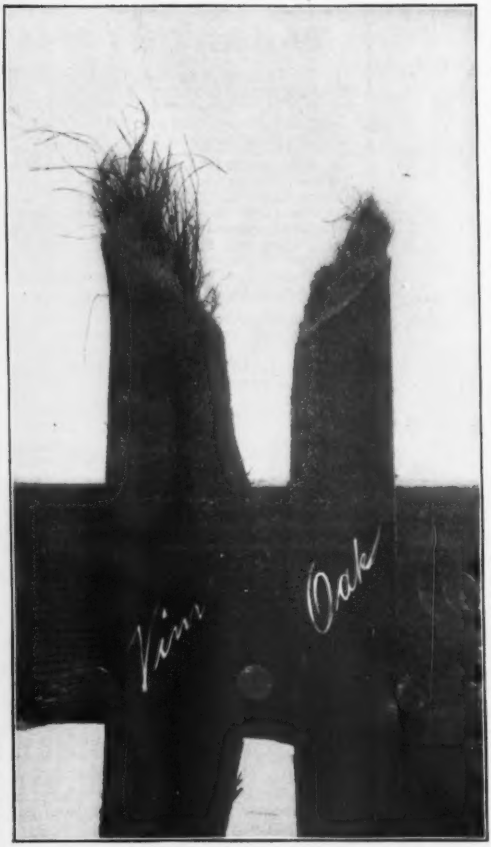

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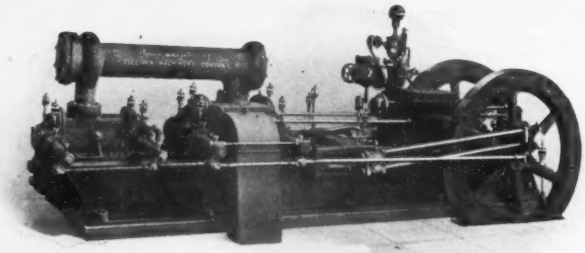

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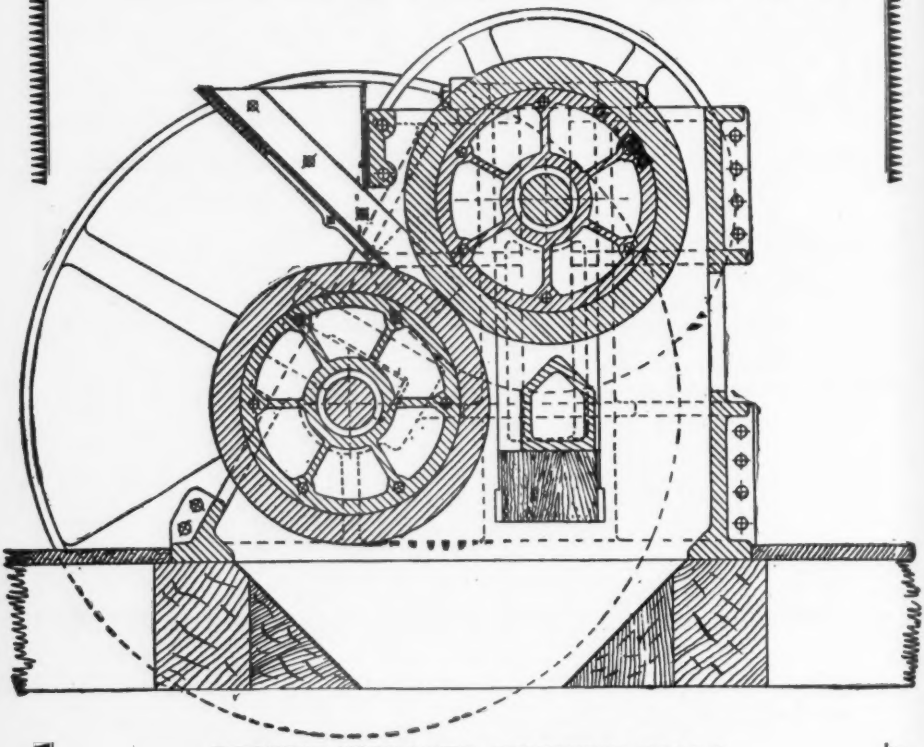

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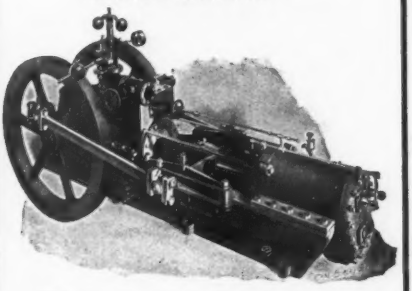

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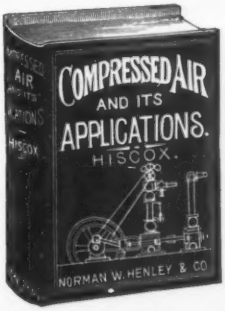

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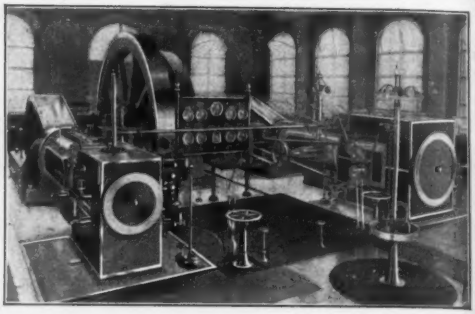

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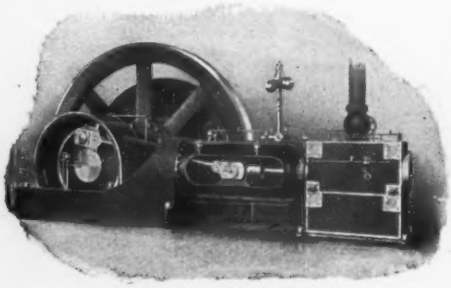

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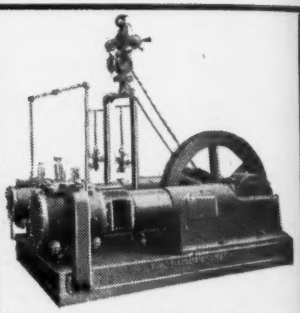

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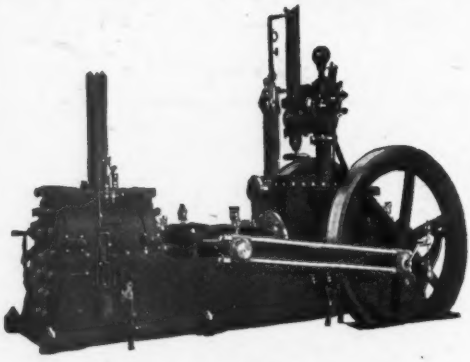

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